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14. ABSTRACT
In 2003, the Allegheny Intermediate Unit received a grant under the National Science Foundation's Math and Science Partnership program to establish the Math Science Partnership of Southwest Pennsylvania (MSP). The MSP brings together regional K-12 school districts, institutions of higher education, and intermediate units with the goals of increasing K-12 students' knowledge of mathematics and science, improving the quality of the K-16 educator workforce, and creating sustainable partnerships among participants. To achieve these goals, the MSP has instituted a variety of activities, including leadership academies, fellowship programs, and networking opportunities, to enact three key intervention strategies: professional development for content and leadership, curriculum alignment and pedagogical and course refinement, and support for and dissemination of research-based resources and tools. As RAND's involvement with the MSP comes to an end (the MSP will continue through 2010), the findings presented here provide preliminary evidence regarding the MSP's progress. The analyses draw on five years of qualitative and quantitative MSP data, including interviews, surveys, participation records, student achievement assessments, and other sources. The findings suggest that MSP partners are making progress toward the three MSP goals, although statistical analysis did not find evidence that the MSP was directly responsible for this progress.

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Math Science Partnership of Southwest Pennsylvania

Measuring Progress Toward Goals

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Prepared for the Allegheny Intermediate Unit

RAND EDUCATION

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Preface

The National Science Foundation's Math and Science Partnership program supports partnerships that unite the efforts of K–12 school districts with those of educators in science, mathematics, engineering, and education departments at colleges and universities. In 2003, the Allegheny Intermediate Unit (AIU) was awarded funding under this program to create the Math Science Partnership of Southwest Pennsylvania (MSP). The MSP brings together K–12 school districts, intermediate units, and institutions of higher education in Southwestern Pennsylvania. Its goals are to increase K–12 students' knowledge of mathematics and science, increase the quality of the K–16 educator workforce, and create sustainable coordination of partnerships in the intermediate units. Initially funded for five years, the project end date was subsequently extended.

AIU subcontracted with RAND Education, a unit of the RAND Corporation, to join an evaluation team that also includes the Collaborative for Evaluation and Assessment Capacity at the University of Pittsburgh and AIU's own evaluation division. Collectively, this team is investigating the effectiveness of the partnership, its impact on practices and policies at partner educational institutions, changes in math and science instruction, and changes in student course taking and achievement.

The five-year term of RAND's subcontract ended in 2008. This monograph describes findings to date regarding the project's progress toward its goals. Notably, it does not constitute a final evaluation of the MSP because the project continues to operate.

This monograph should be of interest to educators and policymakers who are considering or engaged in large-scale efforts to improve mathematics and science education, evaluators interested in methodologies used to assess the value of large-scale reforms, and institutions of higher education that may be interested in partnership efforts with K–12 school districts. The evaluation is part of a larger body of RAND Education work addressing teachers and teaching, mathematics and science achievement, and educational reforms.

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Summary

The National Science Foundation's (NSF's) Math and Science Partnership program began in 2002 with the goals of providing a challenging curriculum for every student, increasing the quality and diversity of mathematics and science teachers, engaging a network of researchers and practitioners in partnership, and disseminating research-based materials. In 2003, the Allegheny Intermediate Unit (AIU) received a grant under this program to establish the Math Science Partnership of Southwest Pennsylvania (MSP).

The MSP brings together 53 K–12 school districts in Southwestern Pennsylvania; four regional, small- to medium-sized, teaching-oriented, private institutions of higher education (IHEs); and four intermediate units (IUs). Its goals are to increase K–12 students' knowledge of mathematics and science, improve the quality of the K–16 educator workforce, and create sustainable coordination of partnerships in the IUs. Initially funded for five years, the project end date was subsequently extended by two years.

The purpose of this monograph is to summarize key findings regarding the project's progress toward meeting its goals. Analyses draw on data collected through the MSP's first five years of implementation, information from surveys of teachers and principals, qualitative data from participating IHEs, educator participation records, and assessments of student achievement.

MSP Intervention Strategies

The MSP used three crosscutting intervention strategies to accomplish its goals. The first is *professional development for content and leadership* through academies and seminars for K–12 educators and IHE faculty. The overriding purpose of these activities is to equip teachers with the content, pedagogy, and leadership skills necessary to become effective leaders in their institutions. The second strategy is *curriculum alignment and pedagogical and course refinement*, enacted at the K–12 level through the use of curriculum frameworks and research-based curriculum materials and at the IHE level through the contributions of K–12 teachers who work with faculty on IHE campuses to refine IHE courses. The third strategy is *support for and dissemination of research-based resources and tools*, primarily through conferences and networks connecting educators using research-based curricula. Importantly, these intervention strategies are not distinct and separable, but rather are intertwined in a design uniting K–12 and IHE educators in working to achieve the goals of the MSP. Table S.1 describes the primary activities used by the MSP to enact these strategies.

Table S.1
Primary Activities of the MSP

Intervention Strategy	MSP Activity	Description
Professional development for content and leadership	Leadership action teams and Leadership Action Academies	Leadership action teams represent each school district and IHE. The teams meet at the Leadership Action Academies to assess the strengths and weaknesses of their institutions and to develop action plans for improvement.
	Teacher Leadership Academies and on-site academies	Teacher Leadership Academies provide professional development on leadership and content for selected teachers, who then lead on-site academies to disseminate the MSP professional development to teachers in their own districts.
	Principal seminars	Seminars for principals aim to build a deeper understanding of effective mathematics and science instruction and to develop effective observing and conferencing techniques.
	Content short courses	Vouchers and stipends support teachers who attend professional development courses in math or science content areas sponsored by IHE partners and others.
Curriculum alignment and pedagogical and course refinement	Teacher fellows	The teacher fellow program provides support for teachers to spend one or two terms at a partner IHE where they work with IHE faculty to refine two IHE courses, take a college course, and participate in MSP activities.
	Curriculum frameworks	The MSP developed a curriculum framework for science and refined the one for math, with the six to eight "big ideas" to be taught in these disciplines at each K–12 grade level.
Support for and dissemination of research-based materials	Network Connections conference	This daylong conference is held twice per year for leadership action teams and other math and science teachers and IHE faculty to explore research-based resources and tools.
	Educator networks	Networking activities assist districts in implementing challenging courses and curricula. Groups of teachers and coaches using a common curriculum meet to share best practices.

NOTE: MSP activities are shown in the table as addressing one specific intervention strategy on which they are likely to have the greatest overall impact. However, most actually address additional intervention strategies. For example, the teacher fellow activity addresses not only curriculum alignment and pedagogical and course refinement, but also professional development for content and leadership.

Evaluation Design

The evaluation questions addressed in this monograph are based on the MSP's goals:

- What progress has been made during the implementation of the MSP toward *increasing K–12 students' math and science achievement*, and to what extent can the progress be attributed to the MSP?
- What progress has been made during the implementation of the MSP toward *increasing the quality of the K–16 educator workforce*, and to what extent can the progress be attributed to the MSP?
- What progress has been made during the implementation of the MSP toward *creating sustainable partnerships*, and to what extent can the progress be attributed to the MSP?

The findings reported here draw on evaluation data related to the project's short-, mid-, and long-term outcomes. It is important to note that the project continues to collect evaluation data. Partners on the assessment and evaluation team are collecting data from case studies of K–12 school districts, observations of MSP events, interviews with key project personnel, and assessments of teacher learning during professional development, as well as continuing to collect and analyze student achievement data.

This monograph describes analyses and findings related to the three evaluation questions. These analyses rely chiefly on mathematics and science achievement data for K–12 students, survey data from K–12 educators, and IHE qualitative data. In addition to these sources, analyses make use of data from a database of educator participation in MSP activities; a statewide database on school district demographics, finances, and achievement; and the project's entries in an NSF-sponsored database that collects information on all math and science partnership projects annually.

Analytic approaches to addressing the evaluation questions can be summarized as follows. Changes in K–12 student mathematics and science test scores are analyzed using three statistical approaches to examine the relationship of those changes to educator participation in the project. Changes in midterm outcomes associated with the quality of the K–16 educator workforce are examined through both qualitative analyses of IHE data and statistical analyses of survey data to examine the relationship of changes to educator participation in the project. Finally, the sustainability of partnerships is examined using indicators drawn from qualitative analysis of IHE data, such as the development of partnership, the implementation of challenging courses through mechanisms established by the MSP, and changes in institutional policies and practices.

Descriptive Summary of K–12 Participation

Over the course of the first four years of the project, 58 percent of mathematics and science educators in the MSP districts participated in project activities. Overall, 3,568 educators participated in math-related activities, and 1,321 participated in science-related activities, though science participation was increasing in the later years. This difference between math and science may be due to the ongoing pressures to improve mathematics achievement, along with the phase-in of lower-stakes state science assessments during the project. On average, the total number of hours that each participant spent engaging in MSP activities over the four years was similar for the two subject areas. The mean total individual participation was 25.1 hours for math and 27.6 hours for science (the medians were 15.0 hours for math and 10.3 hours for science). Combining math and science, the sum of individual-level participation over four years ranged from 0.5 to 306 hours but was in the range of five to 50 hours for most participants.

Overall Findings on MSP Progress Toward Its Goals

Achievement analyses found that MSP school districts experienced trends of increase in student mathematics and science scores during the project. For mathematics, similar trends were observed throughout Pennsylvania; for science, there was no external reference for comparison. Further analyses examined the relationship between educators' MSP participation and students' math and science achievement. MSP participation measures were developed to account for differences in the potential impact of educators who play a leadership role, as opposed to educators who teach but do not play a leadership role. These measures were then used in three distinct analytic strategies for statistically modeling the relationship between educator participation and student achievement. Results of these analyses showed only a few significant relationships between MSP participation by educators and student math achievement. These significant relationships appeared among many nonsignificant findings and were inconsistent across cohorts and analyses—as a result, they do not enable us to draw any overall conclusion about the effects of the MSP on changes in math or science achievement.

Analyses of K–12 survey and IHE qualitative data examined evidence of change in midterm outcomes related to the quality of the K–16 educator workforce. Generally, educators at both the K–12 and IHE levels reported changes in leadership and instruction that are consistent with the MSP theory of action. K–12 teachers reported that MSP activities increased their awareness and understanding of math and science concepts and how students think about math and science and helped them change their teaching practices. They also reported that the professional development in which they participated was more often relevant to their needs and was focused on instructional approaches and individual student learning. Principals reported that the principal seminars influenced their views and behaviors as principals. IHE faculty reported a greater emphasis on student-centered instruction and more awareness of different pedagogical techniques. These findings suggest that the activities of the MSP may be having the intended effect on midterm outcomes associated with increasing the quality of the educator workforce. However, further statistical analyses of the relationship between participation in MSP activities and survey scales tracking key midterm outcomes did not provide evidence that the MSP is responsible for the changes reported by educators. Data from the K–12 case studies may be helpful in interpreting these findings.

IHE analyses examined the development of sustainable partnerships in the MSP and found positive indications of partnership development between IHE and K–12 educators, between IHEs, and between departments within IHEs. Moreover, analyses found modest progress toward a broader definition of scholarship in IHE faculty reward systems, an important factor in partnership development. Participation in MSP activities, along with revisions to IHE courses through the teacher fellow program, helped faculty embrace a wider variety of approaches to presenting the material to their students. As a result of these changes, faculty members were optimistic that students would become more engaged in coursework and take responsibility for their own learning.

Conclusion

In sum, the evaluation found numerous indications that changes are occurring that are consistent with the MSP theory of action. Thus, MSP partners appear to be making progress toward the three MSP goals, though attempts to statistically link this progress to MSP participation were not successful. There are several limitations to note. The evaluation was designed to be selective in its data collection and analyses, primarily assessing the project's achievement of its goals and the major pathways toward achieving those goals. In addition, the evaluation relies on self-report data from a sample of participants and is subject to common potential biases associated with such data. Finally, and importantly, if the MSP intervention strategies require more than four years to achieve project goals, analyses reported here may not detect the impact. This monograph concludes RAND Education's MSP evaluation activities; however, it is important to note that it does not constitute a final evaluation of the MSP. The project, including data collection and evaluation activities, is expected to continue through a forecasted end date in 2010.

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Abbreviations

ADM	average daily membership
AIU	Allegheny Intermediate Unit
IEP	individualized education plan
IHE	institution of higher education
IU	intermediate unit
LAT	leadership action team
MD	mean difference
MSC	Math and Science Collaborative
MSP	Math Science Partnership of Southwest Pennsylvania
NCLB	No Child Left Behind Act of 2001
NSF	National Science Foundation
OSA	on-site academy
PDE	Pennsylvania Department of Education
PI	principal investigator
PROM/SE	Promoting Rigorous Outcomes in Mathematics and Science Education
PSSA	Pennsylvania System of School Assessment
STEM	science, technology, engineering, and mathematics
TF	teacher fellow
TIMSS	Trends in International Mathematics and Science Study
TLA	Teacher Leadership Academy

CHAPTER ONE

Introduction

In 2003, the Allegheny Intermediate Unit (AIU) received a grant from the National Science Foundation (NSF) to establish the Math Science Partnership of Southwest Pennsylvania (MSP). The project's evaluation team comprises the Collaborative for Evaluation and Assessment Capacity at the University of Pittsburgh, AIU's own evaluation division, and RAND Education, a unit of the RAND Corporation. Collectively, this team is investigating the impact of the partnership on practices and policies at partner educational institutions, changes in math and science instruction, and changes in student course taking and achievement.

This monograph examines the MSP's progress, through five years of implementation, toward its three goals of increasing K–12 students' knowledge of mathematics and science, increasing the quality of the K–16 educator workforce, and creating sustainable coordination of partnerships in the intermediate units (IUs).[1] This chapter provides an overview of the national Math and Science Partnership initiative funded by the NSF, followed by an overview of the design and progress of the MSP.

Overview of the Math and Science Partnership Program

The NSF's Math and Science Partnership program began as an initiative of the No Child Left Behind Act of 2001 (NCLB), largely in response to growing concerns about the ability of the United States to remain competitive in a global economy with continued poor performance among students in math and science. NCLB's education reform agenda included recommendations that the following three issues be addressed: too many teachers teaching out of their fields, too few students taking advanced coursework, and too few schools offering challenging curricula and textbooks (NSF, 2002). One year later, Congress established the Math and Science Partnership program under the NSF Authorization Act of 2002 to focus on these issues (see Pub. L. 107-368).

The Math and Science Partnership is an ambitious program. In the initial program solicitation, the following goals were identified in an effort to improve student achievement:

- "[P]rovide a challenging curriculum for every student."
- "[I]ncrease and sustain the number, quality, and diversity" of K–12 mathematics and science teachers "through further development of a professional education continuum."

[1] Pennsylvania's IUs are publicly funded educational service agencies that serve as regional intermediaries between locally controlled school districts and the Pennsylvania Department of Education.

- "[C]ontribute to the national capacity to engage in large-scale reform through participation in a network of researchers and practitioners, organized through the [Math and Science Partnership] program."
- "[E]ngage the learning community in the knowledge base being developed in current and future NSF Centers for Learning and Teaching and Science of Learning Centers" (NSF, 2002).

Although the language in subsequent solicitations evolved, the intent to implement sweeping and sustainable change has remained.

Prior NSF programs targeting math and science educational reform have had similar goals. For example, the Collaborative for Excellence in Teacher Preparation program sought to lift the quality of education received by preservice teachers by involving math, science, and engineering departments (Ruskus, Matson, and Perakis, 2001), and the Local Systemic Change program focused on professional development for in-service K–12 teachers of math, science, and technology (I. Weiss, Banilower, et al., 2002). However, the Math and Science Partnership program is notable in requiring equal participation of K–12 and institutions of higher education (IHEs) in the educational reform. Each program partnership must include one or more school districts and one or more higher education entities as core partners, with additional partners encouraged but not required. Moreover, the Math and Science Partnership program expects full participation from mathematics, science, and engineering faculty members in project activities. It is also clear that the NSF expects substantial institutional change to occur in both K–12 and higher education and that it intends to study partnership models to learn how partners' commitments result in institutional changes that lead to the scalability and sustainability of the reform efforts.

Although there is considerable flexibility in the designs of individual projects, they are expected to incorporate the following key features:

- *Partnerships:* Projects should be designed and implemented through partnerships that unite administrators, teachers, and guidance counselors in K–12 partner organizations, as well as education faculty and disciplinary faculty in mathematics, science, and engineering in partner IHEs.
- *Teacher quality, quantity, and diversity:* Projects should enhance and sustain the number, quality, and racial/ethnic diversity of K–12 mathematics and science teachers.
- *Challenging courses and curricula*: Projects should ensure that K–12 students are prepared for, have access to, and are encouraged to participate and succeed in challenging mathematics or science courses and curricula.
- *Evidence-based design and outcomes:* The project design should be informed by the current literature on learning and teaching, and project outcomes should promise to make evidence-based contributions to the learning and teaching knowledge base.
- *Institutional change and sustainability:* To ensure sustainability, core partner organizations should redirect resources and design and should implement new policies and practices that result in well-documented, inclusive, and coordinated institutional change at both the K–12 and IHE levels.

To date, the program has made approximately 140 awards, totaling nearly $700 million (NSF, 2008). Funded projects have involved hundreds of IHEs and K–12 school districts, along with a host of other stakeholders. Additional projects have been awarded through a parallel Math and Science Partnership program administered by the U.S. Department of Education, also authorized by NCLB. That program requires partnerships to include a state educational agency or public regional intermediary, such as Pennsylvania's IUs, the engineering, math or science department of an IHE, and one or more high-needs school districts. Unlike the NSF program, in which funds are awarded to projects in a national competition, the Department of Education allocates program funds for states to administer.

Overview of the Math Science Partnership of Southwest Pennsylvania

The MSP brings together 53 K–12 school districts—45 as part of the NSF grant and eight additional districts supported by a companion math and science partnership grant from the Pennsylvania Department of Education (PDE)—four IUs, and four IHEs in Southwestern Pennsylvania. Its goals are to increase K–12 students' knowledge of mathematics and science, increase the quality of the K–16 educator workforce, and create sustainable coordination of partnerships in the IUs. The project began in September 2003 with an initial funding period of five years. In 2008, the NSF extended the end date of the project to 2010.

The MSP serves Southwestern Pennsylvania, including the urban fringe of the City of Pittsburgh, several smaller urban areas, suburbs, and rural areas.[2] Most of the school districts participating in the MSP are within the regions served by the four partner IUs; however, five districts are in neighboring regions that are served by other IUs. The school districts in the MSP are relatively small: Total enrollment is approximately 114,000 students, an average of about 2,150 per district. The typical MSP school district has only four or five schools. The MSP districts have a total of approximately 3,400 teachers who teach math or science topics. On average, about 39 percent of students in MSP schools are economically disadvantaged, compared with a statewide average of 36 percent. This figure is higher in the PDE MSP districts (59 percent) than in the NSF MSP districts (35 percent). The enrollment of underrepresented minorities is approximately 19 percent, compared with a statewide average of 22 percent.[3] Again, this figure is higher in the PDE MSP districts (25 percent) than in the NSF MSP districts (18 percent). These demographics vary widely across schools. The reported percentages of both economically disadvantaged and minority populations vary between 0 percent and nearly 100 percent for individual schools.

At the start of the project, there was similar wide variation in student achievement levels across the MSP districts. A substantial portion of MSP schools are not making adequate yearly progress under NCLB; three MSP districts are subject to state control if they do not improve, and one of those is already being operated under a state board of control. At the other end of the spectrum, the MSP includes several "blue-ribbon" schools that are among the highest-achieving in the state. Chapter Four includes additional details about student achievement in MSP schools.

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[2] Pittsburgh Public Schools, the largest urban school district in the region, is not formally involved as an MSP participant. However, district personnel in both mathematics and science have a long history of involvement with a regional collaborative related to the MSP, as discussed in Chapter Two.

[3] Minorities include students identified as black, Hispanic, Asian, or Native American. The great majority of these are black.

The four partner IHEs are small- to midsized, teaching-oriented, private institutions located in Southwestern Pennsylvania: Carlow University, Chatham University, Robert Morris University, and Saint Vincent College. These IHEs have approximately 860 faculty members and 11,300 students. Approximately 55 members of their math, science, engineering, and education faculties are participating in this project. Although some of the larger research-oriented universities in the region were invited to participate in the MSP, they declined. In some cases, the universities were already involved in educational reform programs. For example, the University of Pittsburgh School of Education was already involved in another Math and Science Partnership initiative through the university's Learning Research and Development Center.

Purpose of This Monograph

The purpose of this monograph is to summarize key findings regarding the project's progress toward meeting its three goals of increasing the mathematics and science achievement of K–12 students, increasing the quality of the K–16 educator workforce, and creating sustainable partnerships. Analyses draw on data collected through the MSP's first five years of implementation, information from surveys of teachers and principals, qualitative data from participating IHEs, educator participation records, and student achievement data. Although this monograph concludes RAND Education's MSP evaluation activities, it is important to note that it does not constitute a final evaluation of the MSP. The project, including data collection and evaluation activities, is expected to continue through a forecasted end date in 2010.

Organization of This Monograph

The remainder of this monograph is organized as follows. Chapter Two provides an overview of the MSP intervention strategies, motivation, and organizational structure and management. Chapter Three contains an overview of the evaluation, including a logic model of the project, the evaluation questions, and the design and limitations of the evaluation. Chapters Four through Six describe the progress of the project toward meeting its goals of improving student achievement, increasing the quality of the educator workforce, and creating sustainable partnerships, respectively. Chapter Seven concludes this monograph with a summary of key findings. Three appendixes contain supplemental details regarding analytic methods and results.

CHAPTER TWO

Math Science Partnership of Southwest Pennsylvania

This chapter describes the MSP's intervention strategies, the motivation for its formation, and its organizational and management structure. The MSP's goals are consistent with the objectives of the overall Math and Science Partnership program. To reiterate, they are to increase K–12 students' knowledge of mathematics and science, increase the quality of the K–16 educator workforce, and create sustainable coordination of partnerships in the IUs. The MSP planned three crosscutting intervention strategies to accomplish these goals.

Intervention Strategies

The MSP intervention strategies are as follows:

- *Professional development for content and leadership* is accomplished through academies and seminars for K–12 educators and IHE faculty. The overriding purpose of these activities is to equip teachers with the content, pedagogy, and leadership skills necessary to become effective leaders in their institutions.
- *Curriculum alignment and pedagogical and course refinement* are accomplished at the K–12 level through the use of curriculum frameworks and research-based curriculum materials and at the IHE level through the contributions of K–12 teachers who spend one to two semesters or a summer on IHE campuses, working with faculty to refine IHE courses.
- *Support for and dissemination of research-based resources and tools,* which is accomplished primarily through conferences and support networks connecting educators using research-based curricula.

Importantly, these intervention strategies are not distinct and separable; rather, they are intertwined in a design that unites K–12 and IHE educators in working to achieve the three primary goals of the MSP. Table 2.1 describes the primary activities used by the MSP to enact these strategies.

Professional Development for Content and Leadership

The first intervention strategy, professional development for content and leadership, was designed to create cadres of teacher leaders in partner K–12 school districts. The teachers receive training and then lead professional development efforts in their districts through on-site academies (OSAs). Each K–12 district and IHE designates a leadership action team (LAT) to enact

Table 2.1
Primary Activities of the MSP

Intervention Strategy	MSP Activity	Description
Professional development for content and leadership	Leadership action teams (LATs) Leadership Action Academies	LATs represent each school district and IHE. Each LAT assesses the strengths and weaknesses of its institution and develops an action plan for improvement. The LATs select teachers and administrators to participate in other MSP activities. District LATs meet four times per year at the Leadership Action Academies, and IHE LATs meet as necessary.
	Teacher Leadership Academies (TLAs) On-site academies (OSAs)	TLAs provide professional development on leadership and content for selected teachers, grouped by discipline (math or science) and level of instruction (early learners, elementary, or secondary). The academies meet for 27 days over a three-year period. Participating teachers become leaders of professional development in their own districts, developing communities of learning and holding OSAs to disseminate what they learn in the TLAs.
	Principal seminars	Seminars for principals aim to build a deeper understanding of effective mathematics instruction and to develop effective observing and conferencing techniques. These seminars total 38 hours over a one-year period. The MSP developed an additional module to support science education supervision.
	Content short courses	Vouchers and stipends support teachers who attend professional development courses in math or science content areas sponsored by IHE partners and others, helping them deepen their content understanding.
Curriculum alignment and pedagogical and course refinement	Teacher fellows (TFs)	The TF program provides support for two or more teachers from each district over the five-year grant period to spend one or two terms at a partner IHE. During each term, the TF works with IHE faculty to help refine two IHE courses, takes a college course, and participates in MSP activities.
	Curriculum frameworks	The MSP developed a curriculum framework for science and refined the one for math, with the six to eight "big ideas" to be taught in these disciplines at each K–12 grade level. The frameworks are intended to help make effective teaching of Pennsylvania's academic standards in science and math manageable by enabling teachers to focus their time teaching fewer concepts in more depth.
Support for and dissemination of research-based materials	Network Connections conference	This daylong conference is held twice per year for LATs and other math and science teachers and IHE faculty to explore research-based resources and tools.
	Educator networks	Networking activities assist districts in implementing challenging courses and curricula. Groups of teachers from across the region (MSP and non-MSP districts) who are using the same curricula (e.g., Everyday Math, Connected Math, Investigations) meet to share best practices. State-funded math coaches are convened to support shared learning.

NOTE: MSP activities are shown in the table as addressing one specific intervention strategy on which they are likely to have the greatest overall impact. However, most actually address additional intervention strategies. For example, the TF activity addresses not only curriculum alignment and pedagogical and course refinement, but also professional development for content and leadership.

this strategy. The K–12 LATs nominally include six teachers representing elementary-, middle-, and high-school math and science, as well as a district-level administrator and a guidance counselor; the IHE LATs nominally include faculty and department heads from math, science, and education departments. Each team is charged with creating a strategic action plan to strengthen the teaching and learning of math and science in its institution, particularly courses taken by prospective teachers. An important component of the action plan is to identify teacher leaders and IHE faculty who will participate in Teacher Leadership Academies (TLAs).

The TLAs and OSAs are expected to build the capacity for change among MSP partners by providing training in math and science content as well as pedagogy. These academies are specialized by discipline (math or science) and level of instruction (early learners, elementary, or secondary) and use previously developed professional development materials (described later). Although the selected professional development materials have not been subjected to rigorous empirical tests of their efficacy, they have appeared promising in case studies during pilot testing (Borko, 2004). Using a two-stage train-the-trainer approach, the developers of the materials provided initial training to MSP staff, who delivered it to teacher leaders during the TLAs, who then, in turn, delivered it to district colleagues during OSAs. This approach enabled the MSP to scale the program to reach a large number of teachers. It is generally agreed that the facilitator plays a crucial role in the success of professional development programs, so this strategy poses a potential challenge: Is the professional development ultimately delivered effectively in the OSAs? The field has not yet established whether such a train-the-trainer approach is effective (Yoon et al., 2007).

MSP professional development for leadership is not limited to teachers: Through principal seminars, administrators are given an opportunity to gain a deeper understanding of effective instruction and develop observation and conferencing techniques to support improvements in teacher instructional practices. The following paragraphs describe several of the resources used in the TLAs and principal seminars.

Video Cases for Mathematics Professional Development. This series uses video recordings of instruction to facilitate and deepen the quality of educators' thinking with regard to student learning of mathematics. With video of teachers leading whole-class math instruction, participants are encouraged to analyze the classroom interactions (Seago, Mumme, and Branca, 2003). The format provides an opportunity to stop, consider, and discuss learning interactions in the moment in which an event occurs, something that is not possible during a live classroom lesson (LeFevre, 2003).

Developing Mathematical Ideas. This K–6 series aids teachers in analyzing and comprehending student learning. A facilitator guides teachers through written vignettes of learning events in the classroom, video recordings of episodes from the vignettes, participation in similar math learning events, and discussion (Morse and Davenport, 2000; Schifter, Bastable, and Russell, 1999). Teachers are encouraged to journal about experiences in their own classrooms, including moments of professional or student struggles, for later discussion with colleagues. In its original design, participants met weekly or biweekly for three-hour sessions over eight weeks for each of two seminars; the curriculum has variations for other formats, such as summer seminars (Schifter, Bastable, and Russell, 1999). Teachers rate the seminar series favorably in helping them adjust to a standards-based curriculum and understand the process of student learning (Morse and Davenport, 2000).

Implementing Standards-Based Mathematics Instruction. *Implementing Standards-Based Mathematics Instruction* is a casebook for professional development that provides a framework offering educators a means to evaluate instructional decisions, choices of materials, and learning outcomes, along with case studies affording opportunities to ground these ideas in actual classroom practice (Smith et al., 2000). The casebook is a product of a project titled "Quantitative Understanding: Amplifying Student Achievement and Reasoning" at the University of Pittsburgh's Learning Research and Development Center. The project examined hundreds of middle-school classroom lessons and drew findings regarding what constitutes effective mathematics instruction (Silver and Stein, 1996). A U.S. Department of Education (1997b) white paper identified this intervention as a promising practice, reporting that it helped build capacity for improved mathematics instruction and led to increases in student performance.

Lesson Study. Lesson study calls for a shift in teacher practice and thinking, requiring teachers to work together to write, observe, revise, observe again, and analyze lesson plans. Teachers observe the lesson being delivered in the classroom and engage in professional conversation focusing on how specific students develop content understanding. Following observation, the teams revise the lesson, then a team member implements the revised lesson while the rest of the team observes (Lewis, Perry, and Hurd, 2004). The Japanese credit the practice of lesson study by classroom teachers as a key factor in revolutionizing their educational system (Lewis, 2002; Lewis, et al., 2004; Takahashi, 2000).

National Academy for Curriculum Leadership. This program focuses on building leadership capacity and improving science instruction. Using the curriculum as a focal point, it provides tools and strategies for teams to improve their science programs by selecting appropriate materials and providing professional development to improve the quality of instruction. St. John et al. (2006) found that the program helped districts develop science leadership capacity, and participants reported that it helped them improve the quality of science instruction in their districts.

Lenses on Learning. This seminar series strives to shift thoughts and beliefs away from traditional approaches to leadership in schools and toward those that are consistent with reform efforts (Stein and Nelson, 2003). In these seminars, administrators develop the skills to lead a professional learning community that values dialogue about student learning and instructional change (Nelson, 1997).

Although professional development is based primarily on published materials, the LATs are responsible for other aspects of the MSP professional development requirements, such as determining the goals, timing, location, and means of district support for participants. The LATs use district-specific data in developing these plans, including math achievement data from the Pennsylvania System of School Assessment (PSSA), science achievement data from an assessment administered by the MSP,[1] results from a survey of teacher confidence in math and science content areas, results from the District Profile on Course Completion, and an analysis of strengths, weaknesses, opportunities, and threats, which the LATs completed early in the first year. The work of the LATs is accomplished over four regional meetings per year at Leadership Action Academies, and some teams hold additional meetings in their districts.

Curriculum Alignment and Pedagogical and Course Refinement

The second intervention strategy of curriculum alignment and pedagogical and course refinement is accomplished at the K–12 level through the use of math and science curriculum frameworks. These curriculum frameworks were developed by the MSP and partner organizations in Southwestern Pennsylvania. The curriculum frameworks identify the big ideas that should be taught in each discipline, and at each grade level, for students to meet Pennsylvania's academic standards in math and science. A primary goal is to enable teachers to improve on their prior practice by teaching fewer concepts in greater depth, with less repetition from year to year. In addition, to develop a plan for change in the mathematics and science curricular area, the LATs annually assess their districts using a district development matrix, a tool based on

[1] Until the 2007–08 academic year, Pennsylvania did not administer a statewide science exam. Chapter Four contains additional information about the project-administered science assessment.

the Concerns-Based Adoption Model (Loucks-Horsley and Stiegelbauer, 1991). This tool indicates the stage of the district's transition in the adoption and implementation of challenging courses and curricula at the elementary-, middle-, and high-school levels.

At the IHE level, course refinement is accomplished primarily through the MSP teacher fellow (TF) program. Over the five-year course of the project, the program enables two or more teachers from each district to spend a summer, a semester, or a full academic year at a partner IHE. During each term on campus, it is expected that the TFs will each work with IHE faculty to help refine two IHE courses in which preservice teachers enroll, take a math or science college course, and participate in MSP activities. The TF program is an important MSP activity because it addresses a number of goals: In addition to course revision and refinement, participating teachers receive professional development through their enrollment in college courses. Through course revision, it is intended that IHE faculty will become more familiar with state and national content standards and that TFs will become more familiar with the depth and scope of specific content. Moreover, the TF also becomes a link between the IHE campus and its school or school district, helping to meet the goal of sustainable partnerships.

Support for and Dissemination of Research-Based Materials

The third intervention strategy of disseminating and supporting the use of research-based resources and tools is achieved through several activities. Network Connections conferences, which are held twice per year, include resource-partner fairs during which participants can review materials and speak with representatives from various professional development and curriculum providers. Additionally, educator networks bring together groups of teachers or coaches from across the region who are using common research-based curricula so that they can support each other and share best practices. Finally, two publications, the *Math and Science Collaborative Journal* and *Math and Science Collaborative Coordi-net*, are also important elements of the dissemination strategy. They contain a directory of mathematics and science professional development opportunities in the region, whether sponsored by the MSP or by other organizations, along with reports of MSP activities, new developments, and lessons learned.

Motivation for the MSP

The MSP has its origins in the Math and Science Collaborative (MSC), a regional partnership among K–12 school districts, IHEs, and businesses that was founded in Pittsburgh in 1994. With a few exceptions, school districts in Pennsylvania are small and independently controlled. The regional structure of both the MSC and the MSP provides organizational coherence for multidistrict participation while recognizing that not every district will choose to join. The MSC embraced many of the values that informed the design of the MSP, including a research-based philosophy and organizational principles centered on the use of standards to help guide instruction and promote student achievement. Standards played an important role in the MSC, which originally created district teams to address new national standards in math and science.[2] In 1997, the importance of standards was reinforced with the publication of the results of the Trends in International Mathematics and Science Study (TIMSS). In addition,

[2] The National Council of Teachers of Mathematics produced the Curriculum and Evaluation Standards for School Mathematics in 1989. The National Research Council produced the National Science Education Standards in 1995.

the region was one of 26 jurisdictions that participated in the 1999 TIMSS Benchmarking Study (Tananis et al., 2002). The TIMSS results were pivotal to the origination of the MSP because they demonstrated the importance of standards in setting clear goals and encouraging collegial discussions. Later, when the Math and Science Partnership program was announced, the MSC identified it as an opportunity to strategically apply what was learned from TIMSS as a focus for change in Southwestern Pennsylvania.

Many of the current MSP activities, such as Network Connections and the TLAs, originated in the MSC. The first academies began in 1995, featuring the national standards and a TIMSS resource kit (U.S. Department of Education, 1997a). The academies were quite successful, and, by 1998, many districts in the region had participated. These experiences with the MSC informed the design of the MSP, particularly the importance of leadership, creating district teams to plan for change, providing adequate release time for teachers to participate in professional development, engaging in data-driven decisionmaking, and focusing on research-based resources.

Many of the current partners were also involved in the MSC, with slightly different roles. For example, each of the IHEs was involved with the MSC prior to the start of the MSP, primarily through participation in meetings that showcased university programs. Similarly, the IUs were involved with the MSC, though their role shifted in the MSP model to be collaborators and full *partners* rather than more loosely associated providers of K–12 professional development resources and materials.

The Pittsburgh Public Schools is another example of a long-standing MSC member with an ongoing relationship with the MSP. The district is not a full partner in the MSP due to other commitments; however, its personnel have taken part in MSP activities that are open to non-MSP districts. In addition, early in the project, the Pittsburgh Public Schools co-hosted training sessions attended by MSP coordinators. (The MSP coordinator role is described later.)

Organizational Structure and Management of the Partnership

The organizational structure of the MSP consists of a governing board known as the MSP Cabinet and six project leadership teams focused on math, science, K–12, IHEs, assessment and evaluation, and budget and finance. The project leadership teams have team leaders and project directors who guide the planning of project activities, allocate tasks among team members, and develop updates on progress and challenges for the MSP Cabinet. Project directors are responsible for daily follow-up on the implementation of the team's specific tasks, ensuring that targets are met on schedule, maintaining project documentation, and providing progress updates.

The MSP Cabinet is the core decisionmaking body and has ultimate responsibility for the coordination and implementation of the partnership, including coordination of partners and project leadership teams. The cabinet, which meets monthly, consists of the MSP principal investigator (PI), co-PIs, and team leaders and project directors from the project leadership teams. District representatives are invited to attend cabinet meetings, and several have become regular participants.

The math and science leadership teams are responsible for strengthening teaching and learning in their respective disciplines at the K–12 level. Each of these teams includes an IHE faculty representative as team leader, the MSP PI, additional faculty representatives from the

IHEs, MSP coordinators, and the math or science project director. The IHE leadership team is responsible for strengthening practices in the teaching and learning of IHE mathematics and science. This team includes the PI, one faculty representative from each of the four IHEs, and the math and science project directors. The K–12 team includes the PI, the K–12 project director, representatives from participating IUs, and two school district superintendents. It is responsible for strengthening and supporting district and school-wide understanding and support for effective teaching and learning of math and science. The assessment and evaluation team is responsible for documenting student achievement and evaluating the project. The team includes the project PI and representatives from RAND, the University of Pittsburgh, and AIU. The budget and finance leadership team includes fiscal representatives from all partner institutions and subcontractors and is responsible for financial matters. Each of these teams meets at least quarterly, though many have found the need to meet more frequently in order to plan and monitor progress.

The MSP coordinators are a key component of the organizational structure. A group of math and science educators, the coordinators are responsible for connecting K–12 districts to IHEs and for implementing MSP activities. The coordinators bring a wealth of experience to the MSP, evident in their diverse backgrounds: retired, late-career, and early-career K–12 teachers; K–12 administrators; and a community college teacher. The coordinators were hired by AIU after demonstrating a variety of qualifications, including math or science content knowledge, oral communication skills, conflict resolution skills, understanding of project goals, organizational planning skills, and motivation. They received 25 days of in-service training in the first project year and at least five days in each subsequent year. They also participate in state and national professional conferences. Funding from the MSP grant supports the coordinators, and their work is undertaken primarily under the supervision of the PI.

In the next chapter, we discuss the design of the evaluation, including the logic model and theory of action used by the evaluation team as a framework for its work.

CHAPTER THREE

Evaluation Design

To evaluate the project, the MSP established an assessment and evaluation team that included members of three institutions: the Collaborative for Evaluation and Assessment Capacity at the University of Pittsburgh, AIU's evaluation division, and the RAND Corporation. Collectively, this team provided formative advice to the project, presented interim findings that gauged the project's progress toward achieving its goals, and documented how well the model worked for the benefit of future initiatives that may seek to replicate it. This chapter describes the evaluation design, including the evaluation questions and the logic model and theory of action that guided the evaluation. The chapter concludes with a discussion of the data sources on which we drew for this monograph, a brief overview of the analyses to be detailed in subsequent chapters, and the limitations of the evaluation.

Evaluation Questions

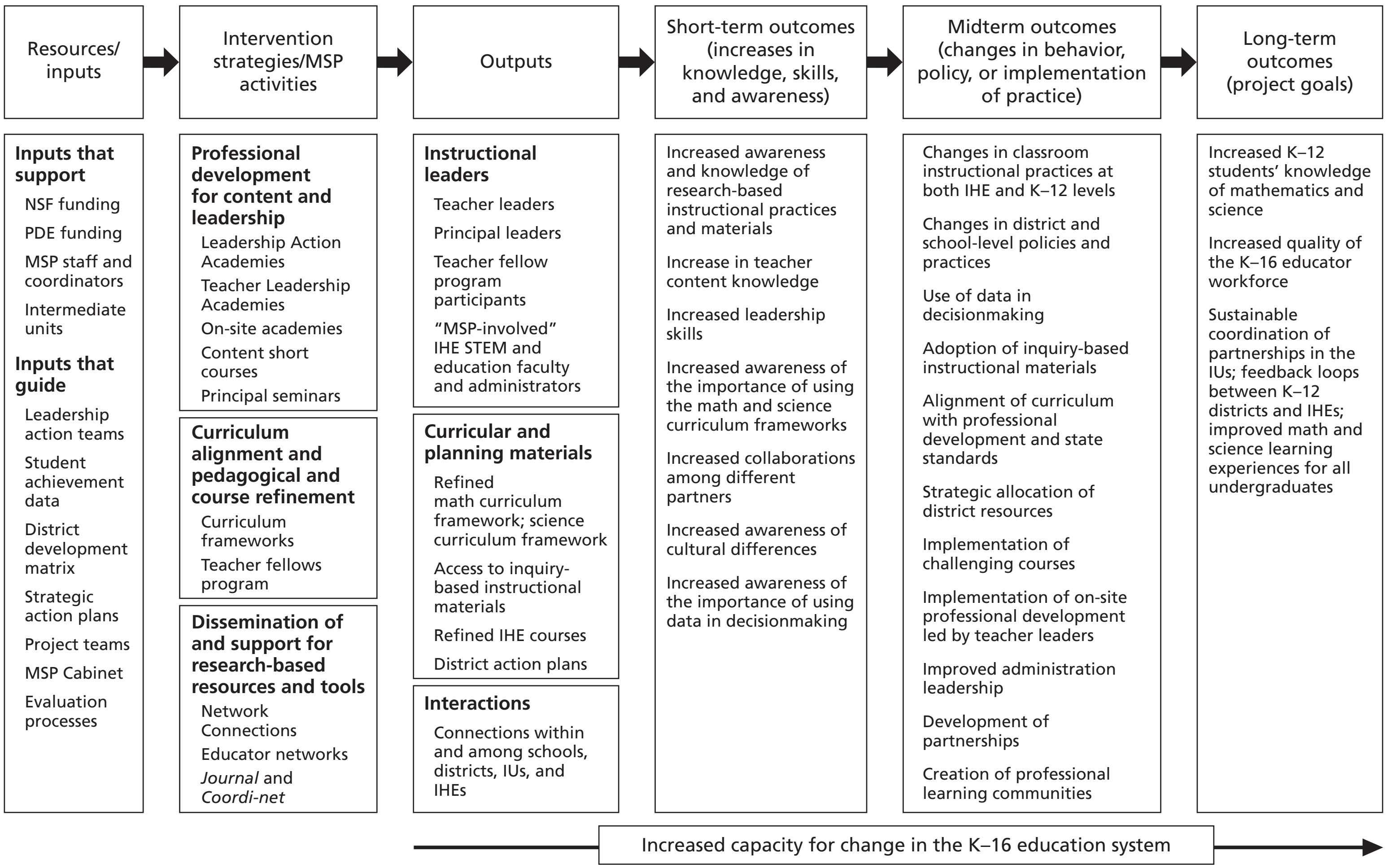
The evaluation questions addressed here are based on the MSP's goals:

- What progress has been made during the implementation of the MSP toward *increasing K–12 students' math and science achievement*, and to what extent can the progress be attributed to the MSP?
- What progress has been made during the implementation of the MSP toward *increasing the quality of the K–16 educator workforce*, and to what extent can the progress be attributed to the MSP?
- What progress has been made during the implementation of the MSP toward *creating sustainable partnerships*, and to what extent can the progress be attributed to the MSP?

Logic Model

The evaluation team consulted with project staff to develop a logic model to guide the evaluation (see Figure 3.1). Logic models are common evaluation tools that offer visual representations of a project's path to achieving its intended outcomes and provide a unified set of terms and relationships to facilitate discussion about the project. This logic model includes the traditional components of inputs, activities, outputs, and outcomes. In the following sections, we describe each component of the logic model diagram, moving from left to right.

Figure 3.1
MSP Logic Model



NOTE: STEM = science, technology, engineering, and mathematics.

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Resources or Inputs

Inputs are the resources that support or guide MSP activities. These include not only funding and human resources, but also materials and expertise. The NSF and the PDE provide the primary funding to support the MSP activities. MSP staff facilitate many of the activities through administrative tasks (e.g., coordinating and maintaining contact with the various partners). As described in Chapter Two, the LATs are the primary resource for providing guidance to the K–12 school districts and IHEs. Materials and tools, such as student achievement data, the district profile of course completion, the district development matrix, and the strategic action plans, are all important in helping the LATs assess and provide the appropriate guidance. The project leadership teams, the MSP Cabinet, and feedback from evaluation processes are also key in providing information that contributes to setting the direction for MSP activities.

Intervention Strategies and MSP Activities

The inputs support the three primary MSP intervention strategies and the associated activities, which were detailed in Chapter Two. These interventions are based, in part, on research on teacher leadership development, teacher change, and communication strategies in learning communities (see, for example, Ball and Cohen, 1999; Loucks-Horsley and Stiegelbauer, 1991; and Senge et al., 2000). The second column of the logic model in Figure 3.1 displays these interventions. Listed below each intervention are the MSP activities that primarily support it.

Outputs

The outputs, in the next column to the right, are the direct and tangible products of the MSP activities. The major outputs from the MSP activities are individuals' exposure to skills and knowledge-enriching activities, positioning them as instructional leaders; materials and tools that can be accessed and utilized for courses, curriculum development, and district planning; and opportunities for interactions and networking. Note that there is not an exact one-to-one correspondence between the MSP activities box and the outputs box. For example, MSP activities listed under professional development for content and leadership not only produce instructional leaders, but also provide access to inquiry-based instructional materials.

Short-Term Outcomes

The next three columns in Figure 3.1 list the expected outcomes that derive from these outputs. In the first of these columns, the logic model defines the short-term outcomes that can be expected for the instructional leaders, such as increases in knowledge, skills, and awareness. Midterm outcomes, then, are the changes in behavior, policy, or practice that occur, presumably, as a result of the increases in knowledge, skills, and awareness.

Midterm Outcomes

The midterm outcomes category of the model is more complex because it reflects the changes that are expected to occur at various levels. For example, in the classrooms, changes in instructional practices are expected; at the school level, changes in policies, such as curriculum alignment and adoption of inquiry-based instructional materials, are expected; at the district level, expectations include improved administrative leadership, implementation of on-site professional development led by teacher leaders, and strategic allocation of district resources; and finally, at the partnership level, the creation of professional learning communities for both

K–12 and IHEs is expected. These changes are not equivalent in terms of the level of effort required; changes in behavior may be easier or more difficult to effect than changes in policies. Moreover, there may be interdependencies among the changes listed as midterm outcomes. For example, improved administrative leadership may need to precede changes in district- and school-level policies and practices. The changes in classroom instructional practices at the IHE level may need to precede the implementation of challenging courses.

Long-Term Outcomes

Collectively, the changes described in the midterm outcomes column should lead to the long-term outcomes, which are defined as the MSP's three goals of increasing K–12 students' knowledge of mathematics and science, increasing the quality of the K–16 educator workforce, and creating sustainable coordination of partnerships in the IUs.

Theory of Action

The theory of action that underlies the MSP logic model is premised on the view that student achievement in mathematics and science can be enhanced by administrators and classroom teachers who are willing to become learners and deepen their own conceptual understanding of the big ideas in mathematics and science (Shaneyfelt, 2005–2006). Similar to the theory of action for the NSF-supported Local Systemic Change Initiative, this theory of action argues that providing teachers with opportunities to deepen their content and pedagogical knowledge in the context of high-quality instructional materials will result in better-prepared teachers (I. Weiss, Banilower, et al., 2002). With ongoing support, teachers will be more inclined to change their instruction in ways advocated by national standards and will have greater capacity to do so. Improved instruction will, in turn, lead to higher student achievement.

This theory of action is supported by a number of research studies. In particular, Catherine Lewis's seminal work on lesson study and research by Japanese and U.S. educators has outlined key pathways to instructional improvement, most of which are mirrored in the MSP logic model (Lewis, 2002; Lewis, Perry, and Hurd, 2004; Takahashi, 2000). These key pathways include increased knowledge of mathematics and science subject matter and instructional approaches to teaching this material, increased ability to observe students, stronger collegial networks, stronger connection of daily practice to long-term goals, strong motivation and sense of efficacy, and an improved quality of lesson plans. Thus, the intervention strategies that the MSP has employed provide mechanisms for achieving program goals along each of these pathways. The TF program, content short courses, and TLAs are routes to achieving increased knowledge of subject matter. The TLAs also serve to increase knowledge of instruction and leadership. Stronger collegial networks are built via a number of routes, including participation in Network Connections, district-led professional development in OSAs, and the educator networks. The emphasis on curriculum alignment and pedagogical and course refinement offers opportunities to improve the quality of instructional materials and lesson plans. However, in addition to these pathways, the MSP theory of action also argues that support from district leadership is an important component of instructional improvement. Administrators can play an important role in supporting teacher-led instructional change through supervision as well as through allocation of resources, such as time for teachers to engage in professional development. Thus, the principal seminars are a key intervention strategy for involving and gaining administrator support. Finally, the role of the IHE in the MSP theory of action is based on the belief that partnerships between K–12 districts and IHEs are mutually supportive and can enhance learning, cultural awareness, and teaching practices for both partners.

Evaluation Data and Analyses

The evaluation data on which we draw are related to the project's short-, mid- and long-term outcomes. Though not a focus of this monograph, it is important to note that the project continues to collect evaluation data, tracking activities, outputs, and outcomes. Partners on the assessment and evaluation team are collecting data from case studies of K–12 school districts, observations of MSP events, interviews with key project personnel, and assessments of teacher learning during professional development. When completed, analyses of those data may help to explain or interpret the findings reported herein.

Each of the following three chapters describes analyses and findings related to the three evaluation questions. These analyses chiefly rely on the following sources of data:

- *Mathematics and science achievement data for K–12 students:* These data include mathematics scores from the 2000–01 through the 2006–07 academic years and science scores from 2003–04 through 2006–07. Student achievement data are described in more detail in Chapter Four.
- *Survey data from K–12 educators:* Baseline and follow-up surveys of principals were administered in 2004 and 2006; the principal of each MSP school was included in the sample. Baseline and follow-up surveys of teachers were administered in 2004 and 2007; a stratified sample of teachers of mathematics or science were surveyed. The surveys are described in more detail in Chapter Five.
- *IHE qualitative data:* IHE qualitative data include semistructured interviews with 56 IHE-related faculty members and administrators, including deans, department administrators, and student-teacher placement coordinators; 10 teacher fellows (at least two from each IHE); four student teachers; and four K–12 teachers who supervised student teachers. Some of these participants were interviewed in two or more years. In sum, a total of 118 interviews were conducted. In addition to the individual interviews, three focus groups were held with teachers who had returned to K–12 instruction after participating in the TF program. The evaluation team also observed one math or science classroom at each of the IHEs and reviewed such documents as IHE course syllabi and curricula, questionnaires regarding course revision, reports prepared by participants, and meeting notes. These data were collected during the 2003–04 through 2007–08 academic years.

In addition to these main sources, our analysis made use of data from a database of educator participation in MSP activities; a statewide database on school district demographics, finances, and achievement; and the project's entries in an NSF-sponsored database that collects information annually on all math and science partnership projects.

The analytic approaches to addressing the evaluation questions, presented in detail in the following chapters, can be summarized as follows:

- Chapter Four examines changes in K–12 student mathematics and science test scores and uses three statistical approaches to examine the relationship of those changes to educator participation in the project.
- Chapter Five examines changes in midterm outcomes associated with the quality of the K–16 educator workforce. The chapter includes both qualitative analyses of IHE data and statistical analyses of survey data to examine the relationship of changes to educator participation in the project. Indicators include increased awareness and knowledge of research-based instructional practices and materials, changes in classroom instructional practices, changes in institutional policies and practices, adoption of inquiry-based materials, and improved leadership.
- Chapter Six examines sustainable partnerships using indicators drawn from qualitative analysis of IHE data, such as the development of the partnership, implementation of challenging courses through mechanisms established by the MSP, and changes in institutional policies and practices that appear to foster or hinder sustainability.

Limitations of This Evaluation

As is commonly the case, this evaluation was selective in its data collection and analyses, primarily assessing the project's achievement of its goals and the major pathways toward achieving those goals. In addition, this study was not implemented as a randomized experiment with a control group, and this fact limits the ability to make definitive causal claims about the MSP's impact. The sparse availability of student achievement scores prior to the start of the project, particularly at the lower grade levels, hinders the ability to assess the project's impact on achievement in elementary schools. Another important consideration is the lack of a statewide science test in Pennsylvania. Although the project administered a science exam to students in participating districts, the exam was not administered widely outside the project, so it was not possible to compare the science performance of MSP districts to external references, such as comparison districts. Until recently, the state administered a math test to students in only a few grade levels, so scores from immediately prior to the start of the MSP are not uniformly available for all students to serve as baselines for math achievement. Lags in the reporting of achievement data forced the evaluation to confine its analyses to test results through the 2006–07 academic year, covering only four full years of MSP implementation in the school districts. If the MSP intervention strategies require more than four years to affect achievement outcomes, the evaluation may not detect this impact. Finally, sparse data linking students to teachers limit the numbers of students, teachers, schools, and districts included in student-level achievement models. To supplement and illuminate the student achievement analyses, the evaluation relies heavily on self-report data from surveys, interviews, and focus groups of a sample of MSP participants. These data are subject to common potential biases associated with such data.

CHAPTER FOUR

Student Achievement

This chapter presents analyses and findings related to the first evaluation question: What progress has been made during the implementation of the MSP toward increasing K–12 students' math and science achievement, and to what extent can the progress be attributed to the MSP? As specified in the MSP logic model and theory of action, the participation of educators in MSP activities is a crucial first step in the pathway to long-term outcomes, such as increases in student achievement. This chapter begins by describing participation information collected by the MSP and how it was used to construct participation measures for use in statistical analyses of student achievement in this chapter and of survey responses in Chapter Five. Next, the various types of student achievement data available for this evaluation are described. Finally, the chapter examines participation and achievement trends, as well as the relationship between educator participation in the MSP and student achievement outcomes.

Measures of MSP Participation

This section describes the database of participation maintained by the MSP and how it was used to construct annual and cumulative participation measures for both individuals and districts.

Participation Database

The MSP project maintains comprehensive information on the level of participation by every educator in MSP school districts who is eligible to participate in project activities, as well as on other participants who are members of non-MSP school districts, IHEs, or other organizations. The project database includes the following information about each participant throughout the duration of the project:

- the number of hours in which the individual engaged in each MSP activity
- the dates of those activities
- institutional affiliation (e.g., district, school, IHE)
- job function (e.g., teacher, principal, superintendent, guidance counselor, professor)
- subject areas taught (e.g., math, science, special education)
- years of experience
- demographic information, such as race/ethnicity and gender.

Development of Participation Measures for Analysis

The evaluation team used information from this database spanning the first four years of MSP implementation[1] to develop individual- and district-level participation variables for use in the analyses. These measures of participation summarize the time spent by educators participating in math or science activities that were identified by MSP staff as most likely to be strongly associated with changes in classroom teaching and student learning. Those activities are as follows: content short courses, educator networks, TLAs, principal seminars, and OSAs. The measure of individual-level participation is defined as the total number of hours that educators spent engaging in these five MSP activities. Excluded from this calculation are activities whose influence over classroom teaching is less direct or potent, including the leadership action teams and academies, the TF program, curriculum framework development, and Network Connections conference participation.

In addition to the individual-level participation measure, three district-level participation measures were developed to summarize the time spent participating in MSP activities by district leaders, mathematics teachers, and science teachers. Participation by leaders and participation by teachers are treated separately because these types of educators have different levels of potential influence over changes in classroom instruction and student learning. Educators are included in the leadership participation measure if they have roles that might enable them to directly influence more than one teacher in the district. These include superintendents, principals, teacher leaders, coordinators, and coaches. Additionally, educators who participated in Leadership Action Academies, TLAs, or educator networks for coaches were counted among leaders for this participation measure because these activities are intended to foster teacher leadership and coaching roles that extend beyond the participants' own classrooms. Therefore, the district leadership participation measure is defined as the total hours of participation by leaders in the five activities listed earlier.[2] This sum is sensitive to both the number of leaders who participated and the amount of time that each devoted to MSP activities.

Each district's remaining MSP participants (those not classified as leaders) were included in the teacher participation measures, which are calculated separately for math and science. The calculation begins by summing the total participation hours of full-time-equivalent teachers, student teachers, substitute teachers, teaching aides, administrators (other than superintendents and principals), counselors, and librarians in the district.[3] This value is then adjusted to create a measure that is not overly sensitive to district size, but instead captures each district's uptake of the participation opportunities afforded by the MSP. The amount of opportunity to participate varies by district according to the number of schools and their configuration, but not school size. The project specifies a maximum number of participants per school that depends on school level: 60 for each elementary school, 20 for each middle school, and 40 for each high school. Thus, the district-level adjusted teacher participation is calculated as the total

[1] The participation measures include only four years of participation data because the latest available student achievement scores are from the end of the fourth year.

[2] For the survey analyses, similar leadership participation measures were calculated at the school level, as described in Chapter Five.

[3] The vast majority of educators included in the teacher measures were identified as classroom teachers by the participation database; however, in a few cases, other roles, such as counselor or librarian, were indicated.

district-level participation hours by teachers divided by the maximum number of teachers in a district who could have possibly participated in MSP training.[4]

Limitations of the Participation Measures

Collectively, these measures enable examination of the relationship between MSP participation and student achievement with available data. However, it is important to recognize that hours of participation is an imperfect measure of all aspects of participation. In particular, the measure does not incorporate information about the quality of the professional development activities or the engagement of educators in these activities, nor does it assess whether teachers successfully enact in their classrooms what they learn in the MSP training. Composites of these factors might produce better measures for examining the relationship between MSP participation and student achievement. The evaluation team explored the development of a valid and reliable composite measure that would consider participant engagement along with hours of participation. This effort, though promising, was not completed in time to be included in this monograph.

Measures of Student Achievement

This section describes the student achievement measures available for mathematics and science and the database of test scores constructed by the assessment and evaluation team.

Mathematics Assessments

Student performance on the PSSA was used to measure mathematics achievement. The PSSA is a standards-based, criterion-referenced assessment used to measure students' attainment of the state's academic standards. The PSSA uses four performance-level descriptors: the *advanced* level reflects superior academic performance, *proficient* reflects satisfactory academic performance, *basic* reflects marginal academic performance, and *below basic* reflects inadequate academic performance. These performance levels are reported publicly for all schools in the state, and the evaluation team is collecting this information. In addition, all MSP-participating school districts are requested to provide student-level PSSA results. Some districts have provided this information dating as far back as the 2000–01 school year. The evaluation team

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[4] The following formulas are used to calculate the district-level adjusted teacher participation variables:

$$\text{District-level adjusted teacher participation in mathematics} = \frac{\text{total participation}_{elementary-all} + \text{total participation}_{middle-math} + \text{total participation}_{high-math}}{\text{total district participation slots available in math}}$$

$$\text{District-level adjusted teacher participation in science} = \frac{\text{total participation}_{elementary-all} + \text{total participation}_{middle-science} + \text{total participation}_{high-science}}{\text{total district participation slots available in science}}.$$

Because elementary teachers usually do not specialize in a particular subject area, participation in math or science activities might influence their teaching of both subjects. Therefore, the sum of elementary teachers' participation regardless of subject area is used in the calculation of district-level teachers' total participation for both subject areas. Although this results in these teachers' participation being counted for both the math and science district-level measures, only one of the measures is used at a time in statistical models, so participation is not double-counted in the analyses.

used available student-level PSSA results from the 2000–01 to 2006–07 school years in the analyses to assess math achievement.

Science Assessments

Until 2008, the PDE did not administer a statewide science exam; at that time, one was initiated for grades 4, 8, and 11. Until this exam appeared, the project annually administered a science assessment based on the 1995 TIMSS that was provided by Promoting Rigorous Outcomes in Mathematics and Science Education (PROM/SE), a math and science partnership at Michigan State University (see Michigan State University, undated). The MSP has no access to science achievement data prior to the start of the project, nor does it have such data from other, non-MSP districts in the state. Moreover, the PROM/SE assessment uses matrix sampling, which does not produce valid student-level scores.[5] Therefore, results must be aggregated across groups of students to produce valid and reliable measures. These results were aggregated to the district level for use in the district-level analysis described next.[6]

Student Test Score Database

The assessment and evaluation team created a database of student-level test scores from MSP districts. Through the 2006–07 academic year, the database contained more than 340,000 math and science scores. Table 4.1 depicts the arrangement of the number of student scores by subject area, year, and student cohort. Table rows represent years, and columns represent student grade levels. Shaded rows indicate years prior to implementation of the MSP. The quantities in the table cells indicate the number of student math and science scores available for a particular cohort of students in a particular year. Math-score counts are indicated by the letter *M*, and science-score counts by the letter *S*. Diagonals represent cohorts of students. For example, the diagonal representing cohort G shows that the database contains about 9,700 scores from when these students took the 8th-grade PSSA math exam in 2003–04 and about 9,300 scores from they took the 11th-grade PSSA math exam in 2006–07. In general, for cohorts of students with pre- and post-tests separated by two or three years, the database contains scores at both time points for about two-thirds of the students.

In addition, the evaluation team requested detailed information about the math and science classes in which students were enrolled and who taught those classes. These student-teacher links were used to examine the association between individual students' achievement and those students' exposure to educators who participated in MSP activities. However, not all districts provided student-teacher link data, and those that did often provided incomplete information. Due to the limited number of students for whom student-teacher links were available, this analysis was feasible for only four cohorts of students. The numbers of students with complete data in those cohorts ranged from approximately 1,840 to 4,100.

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5 In matrix sampling assessment designs, students receive different sets of items. This enables broader domain coverage than when all students receive the same items.

6 Aggregation at the school level was not possible because, in some schools, there was an insufficient number of students tested to produce valid scores.

Table 4.1
Math and Science Achievement Scores, by Year and Cohort

Year	Grade 3	4	5	6	7	8	9	10	11	12	
2000–01			3,847 M			3,941 M			3,441 M		Pre-MSP scores
2001–02			6,001 M			5,584 M			5,500 M		
2002–03			6,054 M			6,261 M			5,602 M		
2003–04		8,261 S	9,145 M		8,933 S	9,696 M			9,059 M		
2004–05	7,648 M	7,873 S	8,985 M		8,700 S	9,914 M		8,115 S	9,005 M		
2005–06	8,870 M	9,429 M 9,091 S	9,595 M	10,199 M	10,631 M 9,516 S	10,852 M		9,176 S	10,324 M		
2006–07	7,800 M	8,051 M 7,664 S	8,051 M	8,541 M	9,137 M 8,448 S	9,086 M		8,273 S	9,298 M		
			Cohort N	Cohort M	Cohort L	Cohort K	Cohort J	Cohort I	Cohort H	Cohort G	Cohort F

NOTE: Table rows represent years, and columns represent student grade levels. Shaded years were prior to the implementation of the MSP. Quantities in cells indicate the number of student math and science scores available for each year and grade level. Math score counts are indicated by the letter *M*, and science score counts by the letter *S*. Diagonals represent cohorts of students.

Analytic Approaches to Relating Student Achievement to MSP Participation

The evaluation team has taken a variety of approaches to analyzing the relationship between MSP participation and changes in student achievement: (1) *student-level achievement models* with linked educator participation, (2) *district-level achievement models* with district-wide leader and teacher participation, and (3) *statewide comparison-group achievement models*. The first two achievement models examine pre-post achievement scores within cohorts of students in MSP schools and attempt to control for the influence of other factors on student achievement. The statewide analysis attempts to isolate the estimates of achievement change from statewide trends in test scores. Despite these careful efforts to control for potential biases, it is important to note that these analyses do not support causal inferences about the relationship between MSP participation and achievement.

Student-Level Achievement Models

In the student-level achievement analyses, the evaluation team examined the association between individual students' achievement change and their linked educators' MSP participation. These analyses were possible for only a fraction of students and teachers, so caution is warranted in interpreting the results. Due to the limited availability of data linking students to teachers across years, the proportion of students who contributed to the analyses ranged from 20 to 45 percent of the students in the analyzed cohorts, and the proportion of teachers ranged from 5 to 15 percent of teachers in MSP districts. However, the included teachers are similar to the larger sample in terms of their average level of participation. The proportion of districts included in these analyses ranged from 25 to 57 percent, and the percentage of schools included ranged from 27 to 70 percent. The represented schools and districts span the range of school- and district-level participation values; this information is presented graphically in Appendix A.

For each cohort analyzed, a multilevel, mixed-effect, cross-classified model was used to predict the post-test scores, using pretest scores, demographic variables (race/ethnicity, gender, and socioeconomic status), and individual-level participation and teaching experience of linked educators in each year as covariates, accounting for the clustering of students in classrooms. Additional details about the models and the variables included in the analyses are presented in Appendix A.

District-Level Achievement Models

As mentioned, student-level analyses were able to examine only a subset of students and teachers due to the absence of student-teacher linkages for many students. To conduct analyses that are inclusive of a greater proportion of students, the evaluation team also considered aggregate analyses at either the school or district level. However, the team determined that the available data did not support school-level analyses. For most cohorts, analyses spanned grade levels in which students typically transition between elementary and middle schools or middle and high schools. Attempting to properly account for the influence of educators on students who spent time in two or more schools would have greatly complicated the analyses. On the other hand, restricting the analyses to students who remained in a single school would have excluded more than half of the schools from the analyses. Moreover, the school-level analysis would have been vulnerable to measurement error. For math, the number of available achievement scores at the school level varied from one to more than 600. For science, 15 different forms of the PROM/SE science achievement test were administered at each school, and the number of students taking each form of the test ranged from two to 40 per school. As a result of these factors, the evaluation team focused on conducting district-level achievement analyses.

The analyses examine the association between district-level achievement change and district-level educator participation. All students in the analyzed cohorts for whom pre- and post-MSP test scores were available were included in the analysis. Where few of the district's math teachers participated in the MSP, any impact of those participants would be diluted by inclusion of students of nonparticipating teachers. However, the MSP is a district-wide intervention expected to contribute to the improvement of mathematics and science achievement among all students. In these analyses, a linear regression model was used to predict district-level aggregated math achievement according to several factors: prior district-level aggregated math and reading achievement; the ratios of female, minority, and economically disadvantaged students; district-level leaders' total participation; and adjusted teachers' participation. As leaders' participation in math and science might influence teaching and learning in both subject areas, the sum of leaders' participation hours in math and science was included in the regression model. Moreover, the adjusted teachers' participation in math or science was used in the corresponding regression models. Additional details about the models and the variables included in the analyses are presented in Appendix A.

Statewide Comparison Group Achievement Models

Because the MSP project design did not include a control group, the evaluation team used an alternative method to form comparison groups of school districts. The primary objective in forming such comparison groups was to make them as equivalent as possible to the treatment group (the MSP districts) at the start of the project. In cases in which student achievement analysis is planned, equivalence on achievement and other variables associated with achievement is desired. To the extent that equivalence is attained, subsequent achievement differences between the groups might plausibly be attributed to the treatment (participation in the MSP). However, there is a risk that, even if the groups appear to be equivalent on the observed variables, there may be preexisting differences between the groups that affect achievement. Thus, this analysis is not as rigorous as would be afforded by an experimental design, in which randomization helps ensure that the groups are equivalent on both observed and unobserved variables.

The comparison groups were formed from other school districts not participating in the MSP. Pennsylvania school districts were selected because state-controlled factors, such as testing and accountability, are the same as for the MSP districts, and because achievement results are publicly available for all of the districts. The evaluation team utilized an extensive set of variables, measured prior to the start of the project, in a method known as propensity weighting (Hirano, Imbens, and Ridder, 2003; Rosenbaum, 1987). The variables, assembled by RAND for a study by McCaffrey and Hamilton (2007), included

- *student achievement:* mathematics and reading PSSA achievement test scale scores for fifth-, eighth-, and 11th-grade students from 1998 to 2003 and trends of change in those scores
- *student demographics:* the percentages of students in racial/ethnic groups and low-income families
- *district finance and staffing:* enrollment, attendance, graduation rates, number of teachers, pupil-teacher ratios, teacher years of experience, teacher salaries, instructional expenses, taxable property values, and local tax revenues
- *2000 census measures:* employment, education, and income of the population living in each school district; property values; rents; and the proportion of female-headed households.

A first comparison group included all non-MSP school districts in Pennsylvania except the Pittsburgh and Philadelphia city school districts (because their characteristics as large urban districts make them very different from the MSP districts) and one district that did not have any enrolled students. A second comparison group was similar to the first, except that school districts participating in the Philadelphia Math and Science Partnership project were also excluded from the comparison group. Finally, a third comparison group further excluded districts in Southwestern Pennsylvania that were not part of the MSP project but nonetheless participated in some MSP activities. After creating the groups, balance was assessed on all of the variables used in matching. Most balanced well, and those that did not were included as covariates in subsequent statistical models. Appendix A includes tables of the covariates and their balance.

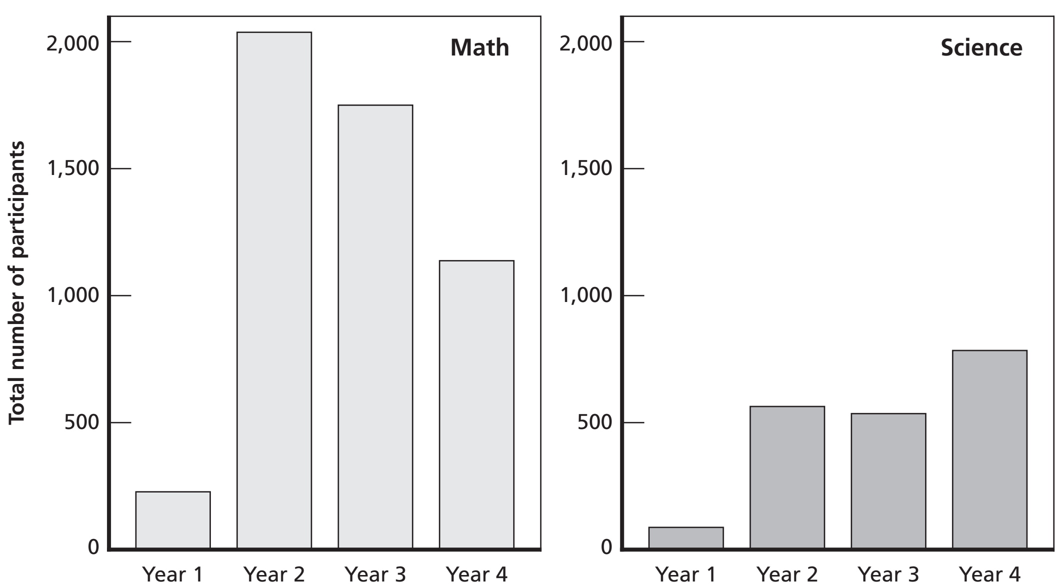
Because no statewide science exam is administered and the comparison districts did not administer the PROM/SE science achievement test, this comparative analysis is confined to math achievement. The PDE discontinued publicly reporting scaled scores in 2004, so proficiency levels were used in models that assess changes in achievement since the project began. Specifically, this analysis uses the percentage of students scoring advanced or proficient on the PSSA. Separate models were run for each cohort of students for which PSSA mathematics proficiency levels were available for both 2003–04 or earlier (as a pre-MSP measure) and 2006–07 (as a post-MSP measure). Additional details about the models and the variables included in the analyses are presented in Appendix A.

Descriptive Summary of Participation by K–12 Teachers and Leaders

Over the course of the first four years of the project, 58 percent of mathematics and science educators in the MSP districts participated in project activities. Overall, 3,568 educators participated in math-related activities, and 1,321 participated in science-related activities, though science participation was increasing in the later years. About 6 percent of elementary-school teachers participated in both math and science activities. Figure 4.1 displays the trends in the number of educators participating each year by subject area. The difference between math and science may be due to ongoing NCLB-related pressures to improve mathematics achievement, along with the phase-in of lower-stakes state science assessments over the course of the project.

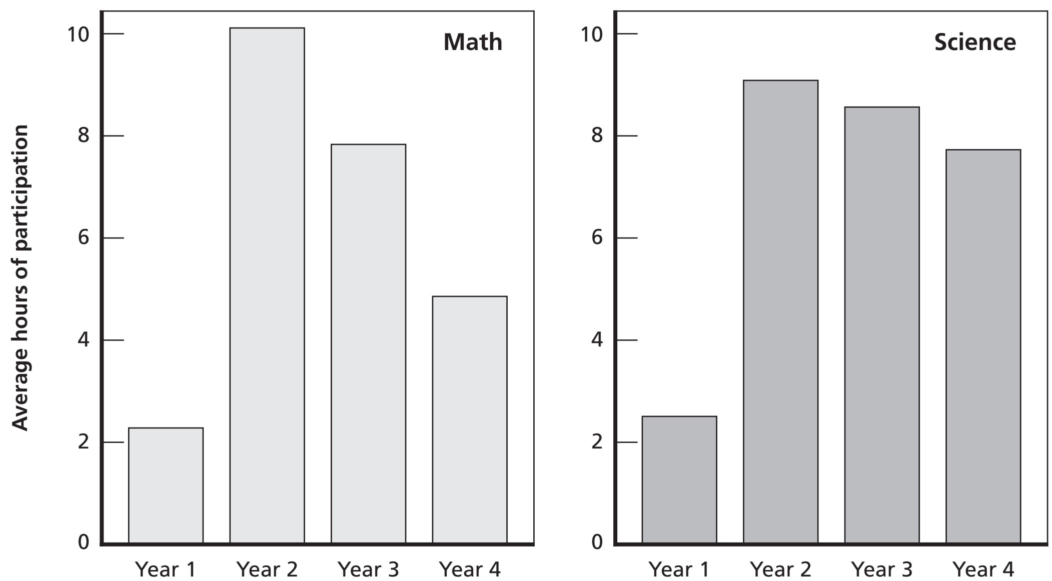
Figure 4.2 shows individual-level participation in math and science across the first four years of the project. For both subject areas, average individual-level participation started low in the first year, reached a peak in the second year, and diminished over the third and fourth years. On average, the total number of hours that each participant spent engaging in MSP activities over the four years was similar for the two subject areas. The mean total participation for individuals was 25.1 hours for math and 27.6 hours for science (the medians were 15.0 hours for math and 10.3 hours for science). Combining math and science, the sum of individual-level participation over four years ranged from 0.5 to 306 hours but was in the range of five to 50 hours for most participants. During years 3 and 4 of the project, the average hours of

Figure 4.1
Trends in the Number of Participants in MSP Activities



RAND *MG857-4.1*

Figure 4.2
Trends in Average Time Spent by Participants on MSP Activities



RAND *MG857-4.2*

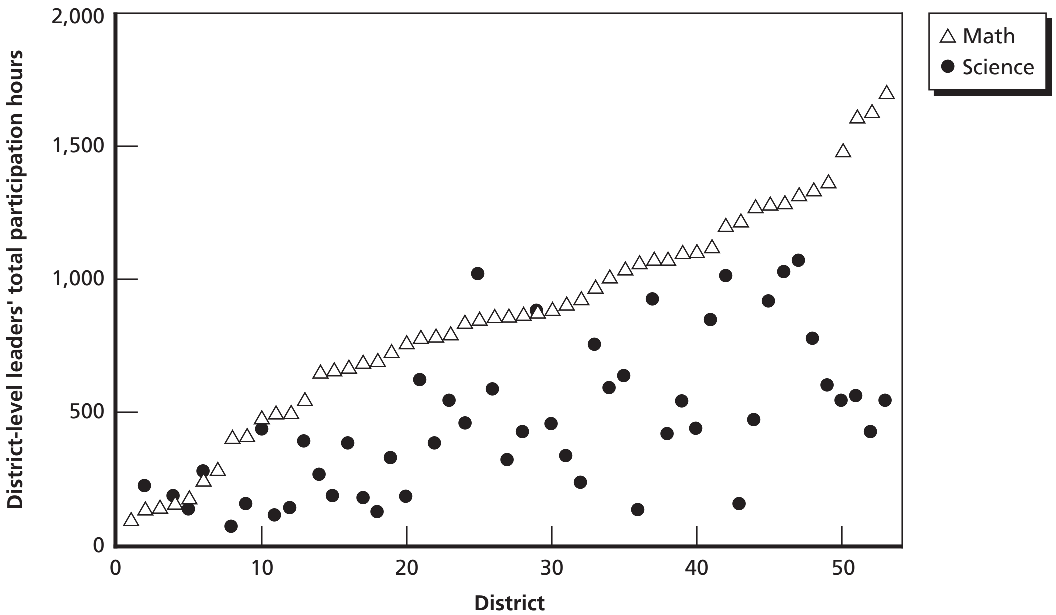
individual-level participation decreased faster in math than in science. This may be a natural result of the staggered implementation of various TLA and OSA activities in math and science.

Across districts, the number of participants and their hours of participation varied considerably. For example, one district had three participants, one who participated for four hours and two who participated for 44 hours each; a second district had 83 participants, with 75 percent participating for more than 10 hours; a third district had 155 participants, with 84 percent participating for more than 10 hours; and a fourth district had 13 participants, all of whom participated for more than 10 hours. Across all districts, the proportion of teachers who participated ranged from 4 to 81 percent.

Over the course of four years, district-level leaders' total participation in math-related activities ranged from 92 to 1,702 hours. Leaders' total participation in science-related activities ranged from 70 to 1,068 hours. For most districts, leaders' total participation in math was greater than in science, and math participation varied more than science participation (see Figure 4.3). For teachers, the average adjusted participation in math, 9.4 hours, was slightly higher than in science, 8.7 hours (see Figure 4.4).[7] There is a relatively strong correlation between the district-level measures of leaders' and teachers' participation: The correlation between total leader participation and adjusted teacher participation is 0.69 in mathematics and 0.70 in science ($n = 53$, $p < 0.05$).

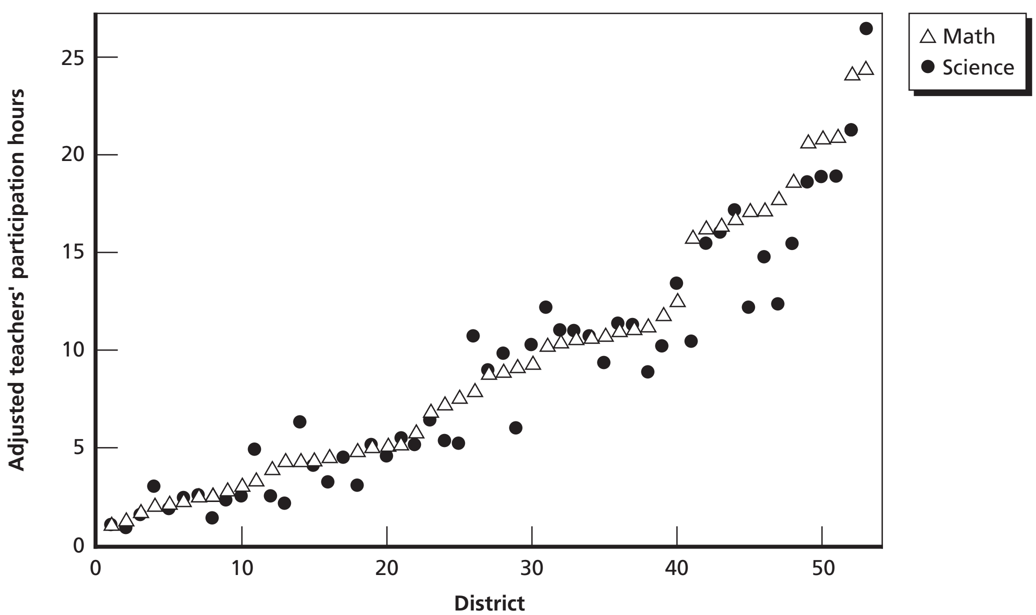
[7] As described in the section "Development of Participation Measures for Analysis," district-level teacher participation was adjusted to account for large variations in district size.

Figure 4.3
Participation in Math and Science MSP Activities by District Leaders



NOTE: Districts are shown in rank order by leaders' participation in math activities.
RAND *MG857-4.3*

Figure 4.4
Adjusted Participation in Math and Science MSP Activities by Teachers



NOTE: Districts are shown in rank order by adjusted teacher participation in math activities.
RAND *MG857-4.4*

Trends in Mathematics and Science Achievement

As a first look at achievement change during the project, the evaluation team examined overall proficiency levels in MSP school districts. This revealed an increasing trend from 2003–04 to 2006–07 in the percentage of students performing at or above the level of proficient on the PSSA mathematics test (see Table 4.2.).[8] This result is encouraging, but it does not rule out the possibility that factors other than participation in the MSP contributed to the increase in proficiency. To conclude that the MSP was the source of the trend would require knowing how attainment of proficiency would have evolved had the project not been undertaken. Of course, we cannot observe such data, but as a coarse proxy for this alternative outcome, we examined the trend in proficiency levels in non-MSP school districts in the state. If the MSP were responsible for the observed trend in participating districts' student proficiency, the trend should be

Table 4.2
PSSA Mathematics Proficiency Levels in MSP and Non-MSP Districts

		MSP Districts				Non-MSP Districts in Pennsylvania			
Year	Grade	Percentage	Std. Dev.	Min (%)	Max (%)	Percentage	Std. Dev.	Min (%)	Max (%)
2003–04	**Overall**	**55**	**0.17**	**13**	**85**	**60**	**0.11**	**15**	**88**
	Elementary	64	0.18	17	93	66	11.63	19	93
	Middle	54	0.20	14	85	61	13.01	13	92
	High	48	0.19	3	81	52	13.76	6	90
2004–05	**Overall**	**65**	**0.15**	**30**	**90**	**69**	**0.09**	**23**	**91**
	Elementary	76	0.13	45	96	79	0.09	29	97
	Middle	59	0.20	14	90	66	0.12	21	92
	High	48	0.19	13	81	53	0.13	5	89
2005–06	**Overall**	**67**	**0.15**	**36**	**89**	**71**	**0.09**	**23**	**92**
	Elementary	77	0.12	49	94	79	0.09	29	97
	Middle	64	0.17	27	93	69	0.11	21	93
	High	51	0.18	8	84	53	0.13	7	90
2006–07	**Overall**	**68**	**0.15**	**33**	**92**	**72**	**0.09**	**20**	**92**
	Elementary	77	0.13	39	95	80	0.09	28	96
	Middle	66	0.17	27	94	72	0.11	15	93
	High	52	0.18	5	82	55	0.13	3	90

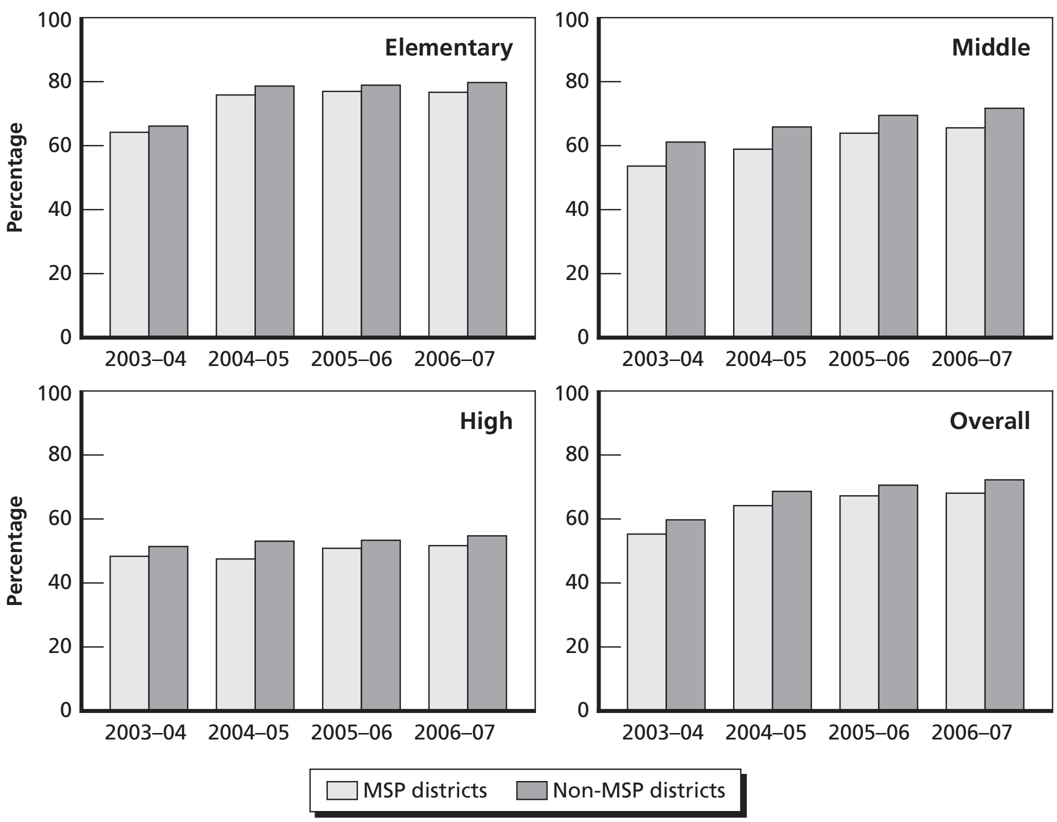
NOTE: For the grade-level breakdowns, all PSSA exams administered in grades 3–5 were classified as *elementary*, those administered in grades 6–8 were classified as *middle*, and the grade 11 exam was classified as *high*. PDE began administering the PSSA in additional grade levels during the course of the project, so the number and types of exams included in the table vary across years, as discussed in the text.

[8] This analysis includes 48 MSP districts, excluding MSP expansion districts that joined the project in year 4.

absent or weaker in non-MSP districts.[9] The results revealed that the proficiency trend from 2003–04 to 2006–07 in non-MSP school districts was similar to that of MSP school districts (see Figure 4.5).

Because there is no proficiency standard for the PROM/SE science achievement test, we calculated the average of district-level standardized science scores. Similar to the trend in math scores, the results showed that, over the past four years, there has been a slight improvement in the mean of these district-level average scores on the PROM/SE assessment (see Table 4.3).[10]

Figure 4.5
Proficiency Levels in MSP and Non-MSP Districts



NOTE: Each panel shows the percentage of students at or above proficient on the PSSA assessments in the 48 MSP districts and other districts in Pennsylvania during the 2003–04 through 2006–07 academic years. For the grade-level breakdowns, all PSSA exams administered in grades 3–5 were classified as *elementary*, those administered in grades 6–8 were classified as *middle*, and the grade 11 exam was classified as *high*. MSP expansion districts that joined the project in year 4 are excluded from both groups. The figure includes all PSSA exams administered each year. PDE began administering the PSSA in additional grade levels during the course of this project, so the number and types of exams included in the figure vary across years, as discussed in the text.
RAND *MG857-4.5*

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9 This evidence would be somewhat weak, however, because the analysis does not attempt to establish that the MSP and non-MSP groups were similar at the start of the project in terms of important factors related to achievement (such as background characteristics of the students). The statewide analyses presented later in this chapter attempt to better control for such factors.

10 Pennsylvania districts outside of the MSP project did not administer the PROM/SE assessment, so no statewide science achievement comparison was feasible.

Table 4.3
MSP District Science Assessment Scores

Year	Mean District-Level Average Score[a]	Std. Dev. of District-Level Average Scores	Number of Districts	Minimum District-Level Average Score	Maximum District-Level Average Score
2003–04	–0.06	0.32	47	–1.03	0.56
2004–05	–0.05	0.30	46	–0.76	0.46
2005–06	0.04	0.31	47	–0.64	0.56
2006–07	0.06	0.32	45	–0.82	0.62

[a] Student-level scores for each form of the PROM/SE assessment were standardized so that the 2003–04 scores had a mean of zero and standard deviation of one. The district average is the mean of the standardized student scores, and the values reported here are the means of the district averages.

Because non-MSP districts do not administer the PROM/SE assessment, the evaluation team was unable to compare these results with those of other districts in the state, so it is not known whether the increases observed in MSP districts reflect statewide trends as they do in math.

Relationship of MSP Participation to Student Achievement

Achievement models, discussed earlier and in Appendix A, tested whether participation, as measured by the individual- and district-level participation measures, is related to student achievement after controlling for pre-MSP test scores and other predictors of future achievement. These analyses focused on students for whom the database contained pre-MSP and post-MSP test scores. Appendix A contains details about the models we ran, the variables included in the models, and full results from each model.

Relationship of Participation to Math Achievement

Table 4.4 summarizes the cohorts on which each type of model was examined. Students in cohorts G and J had math achievement scores in 2003–04 (the last pre-MSP year) and 2006–07 (three years after MSP implementation). The time span between the two tests gave these students the maximum amount of exposure to educators who had undertaken MSP training. In the student- and district-level analyses, additional cohorts were examined where the pre- and post-tests spanned fewer years and for which the pretest was not a true pretest because it was obtained after project implementation had begun. Analyses of cohorts K and M cover two years of implementation, and those of cohorts L and N cover one year. In the student-level analyses, the lack of a sufficient number of students linked to educators prohibited analyses of cohorts J and M.

In total, four cohorts were examined in student-level achievement models, six cohorts were examined in the district-level achievement models, and two cohorts were examined in the statewide comparison models. As shown in Table 4.4, for two cohorts, one of the analyses detected a significant positive relationship between participation of certain educators and achievement. However, in both cases, the same models produced less positive results for other educators, as discussed in the table notes. Moreover, the positive findings were not replicated in additional cohorts or types of analyses (student-level, district-level, or statewide comparison).

Table 4.4
Summary of Mathematics Achievement Models

	Cohort					
Mathematics Analyses	**G**	**J**	**K**	**L**	**M**	**N**
Student-level models			+[a]			
District-level models						
Statewide comparison models		+[b]				

NOTE: Shaded cells indicate cohorts for which models were run. Cells with plus-signs indicate models in which a significant positive effect was detected ($p < 0.05$, not adjusted for multiple-hypothesis testing). Refer to Table 4.1 for additional information about the cohorts and Appendix A for technical details about the models.

[a] This model linked students to their mathematics teachers in sixth and seventh grades and examined mathematics achievement over this two-year period. The model detected a positive relationship between MSP participation of the sixth-grade teachers and student achievement. No effect was detected for the seventh-grade teachers.

[b] This model examined district-level aggregate math achievement over a three-year period when students were in sixth through eighth grades, with participation of leaders, mathematics teachers, and science teachers included as covariates. The model detected a positive effect for leaders. No effect was detected for mathematics teachers. These results were stable across the three matched comparison groups described in Appendix A. For science teachers, a significant negative relationship was detected for two of the three comparison groups.

Overall, we conclude that (1) these analyses do not find a coherent relationship between educator participation in the MSP and students' math achievement and (2) the few significant relationships that were detected should not be overinterpreted or overgeneralized.

Relationship of Participation to Science Achievement

For MSP participation and science achievement, the available data enabled the evaluation team to conduct only the district-level analysis. The student-level and statewide comparison analyses were not feasible because individual-level science achievement scores were not comparable and the comparison districts did not administer the same science achievement test as the MSP districts did. Based on the available data, the evaluation team examined eight cohorts of students, shown in Table 4.5. Results of these analyses showed no significant positive relationships between district-level leaders' or teachers' MSP participation and students' science achievement.

Table 4.5
Summary of Science Achievement Models

	Cohort							
Science Analyses	**F**	**G**	**H**	**I**	**J**	**K**	**M**	**N**
District-level models								

NOTE: Shaded cells indicate cohorts for which models were run. These models detected no significant effects. (See Table 4.1 for additional information about the cohorts.)

Summary of Findings Related to Student Achievement

In summary, this chapter examined the relationship between educators' MSP participation and students' math and science achievement at the individual and district levels. To do this, the evaluation team developed participation measures that accounted for differences in the potential impact of participants who play a leadership role, as opposed to those who teach but do not play a leadership role. The evaluation team used these measures in three distinct analytic strategies to statistically model the relationship between participation and achievement and ran these models on multiple cohorts of students. Ideally, the results of these varied analyses would align to form a coherent picture of the effect of MSP participation on achievement and help to overcome the limitations of this project's nonexperimental design.

Results of these analyses showed only a few significant relationships between MSP participation by educators and student math achievement. These significant relationships appeared among many nonsignificant findings and were inconsistent across cohorts and analyses. As a result, they do not enable us to draw any overall conclusions about the effects of the MSP on changes in math or science achievement.

There are some possible explanations for why an impact of educators' MSP participation on learning may not be detectable at a statistically significant level in these analyses. For example, the participation measure based on hours is imperfect and does not consider such potentially important factors as the engagement of educators in the activities. Moreover, the PSSA mathematics and PROM/SE science assessments used in this analysis may not be sensitive enough to the changes in student learning that might result from the MSP intervention. Finally, teachers may not have had sufficient time to enact in their classroom teaching what they learned in MSP professional development activities, or students may need to be exposed to these changes in teaching for an extended period before showing gains on assessments. Partners on the assessment and evaluation team continue to collect and analyze achievement data as well as case study data that may yield useful information for interpreting the achievement results.

CHAPTER FIVE

Quality of the Educator Workforce

The second MSP project goal is to increase the quality of the K–16 educator workforce. As discussed in Chapter Three, the theory of action stipulates that providing teachers with opportunities to deepen their content and pedagogical knowledge in the context of high-quality instructional materials will result in better-prepared teachers. The MSP implemented several activities for both K–12 and IHE educators to achieve this goal. Through participation in the principal seminars, principals were exposed to reform-oriented teaching practices and appropriate methods to observe and frame discussions with teachers. K–12 teacher leaders and IHE faculty were exposed to various pedagogical techniques and leadership training in the TLAs. K–12 educators were exposed to research-based educational materials and other reform-oriented practices through other MSP activities, including content short courses, OSAs, the teacher fellow program, and educator networks.

Because it is difficult to measure increases in the quality of the educator workforce directly, analysis of the impact of the MSP focuses on short- and midterm outcomes associated with the quality of the educator workforce. These include

- increased administrative leadership skills
- changes in district- and school-level policies and practices
- increased awareness and knowledge of research-based instructional practices and materials
- changes in instructional practices
- creation of professional learning communities.

This chapter uses survey data to examine changes in these outcomes over the course of the project, as well as the relationship of MSP participation to the observed changes. The chapter also examines IHE interview and observation data related to the quality of the educator workforce.

Survey Development and Analysis

During the project, we administered surveys to math and science teachers and the principal at each MSP school. Surveys were administered twice during the project, and we refer to these as *baseline* and *follow-up*, respectively. The baseline teacher survey was administered in the spring of 2004 after one year of MSP planning but before most teachers had become engaged in the project. Of the approximately 3,200 teachers in participating school districts, we selected a sample of 1,881, stratified by level (elementary, middle, or high school) and topic area (mathematics, science, or both).[1] We administered a follow-up survey to teachers three years later in the spring of 2007. All who responded to the baseline survey were included in the follow-up sample if they were still teaching in the district, and remaining surveys were allocated using a stratified sampling method similar to that used for the baseline survey. Responses were received from 1,241 (66 percent) of the 1,881 teachers sampled for the baseline survey and 1,574 (79 percent) of the 1,988 teachers sampled for the follow-up survey.

The baseline principal survey was administered to the principal of each MSP school in the fall of 2004, and the follow-up was administered in the fall of 2006. There was greater than 40-percent turnover in principals over this two-year period, so caution is warranted in interpreting changes from baseline to follow-up. Observed changes may accurately reflect changes in the views and attitudes of the schools' leadership over this period but may not represent changes in the views or attitudes of individuals. Responses were received from 142 (71 percent) of the 201 principals sampled for the baseline survey and 181 (92 percent) of the 197 principals sampled for the follow-up survey.

The teacher and principal surveys were designed to capture educators' views and attitudes about science and mathematics instruction; current practices and policies in curriculum, instruction, assessment, and professional development; district and IU support for improving schools; and MSP project impact. The teacher survey was primarily a subset of questions from the Surveys of Enacted Curriculum produced by the Council of Chief State School Officers. We selected the Surveys of Enacted Curriculum based on their ability to measure the types of teacher practice and course-content reforms targeted by the MSP intervention (Porter, 2002). Items on the principal survey were adapted from survey instruments developed by Horizon Research, Inc., the Center for the Study of Teaching and Policy, and the Center for Research on the Context of Teaching and from principal rubrics developed by Richard Halverson at the Wisconsin Center for Education Research. The majority of the questions on the baseline and follow-up surveys were identical, but some new MSP-specific items were added to the follow-up teacher and principal surveys to try to understand the impacts of MSP activities and factors that influenced participation.

We made use of imputation to enable inferences about educators in all MSP schools in some analyses. Specifically, for each of the four surveys (baseline and follow-up, teacher and principal), we imputed responses that were missing on surveys that we received. Additionally, we imputed response values for the entire survey for nonrespondents to the baseline and follow-up principal survey and for nonrespondents to the follow-up teacher survey. Those surveys each had a response rate of 71 percent or higher. A limitation of imputation is that it relies on data from respondents with similar characteristics to the nonresponders. If the nonresponders are dissimilar to responders on measured or unmeasured characteristics, the imputed values can be unreliable. This concern is mitigated somewhat because response rates were relatively high on these surveys, and our inspection of imputation results did not reveal any anomalies. Additionally, fully imputed surveys for nonrespondents were not used in analyses of teacher change from baseline to follow-up because those analyses focused on 798 teachers who responded to both the baseline and follow-up surveys (the 798 respondents were roughly evenly divided

[1] Elementary-school teachers typically do not specialize by topic area and teach both mathematics and science.

between math and science teachers). Appendix B contains additional information about survey development, sampling, imputation, and analysis.

Principal Survey Scales

For the principal survey, we used factor analysis to develop 27 scales representing subsets of highly correlated items. Table 5.1 displays the scales along with their reliability, which generally exceeds 0.75. Eight sets of scales were derived from questions asked twice on each survey: once regarding science and once regarding math. Reliabilities are reported separately for those scales. The remaining scales are not specific to math or science.

Teacher Survey Scales

Similar methods were used to develop scales for the teacher survey. Twelve scales were formed from items appearing on both the baseline and follow-up surveys, and seven from items appearing only on the follow-up. These scales are shown in Table 5.2. The follow-up survey also included items inquiring about each MSP activity, resulting in a pair of scales for each activity. Generally, the teacher survey scales had reliabilities of 0.70 or greater.

Approaches to Survey Analysis

Using these scales, we performed three general types of analyses: (1) descriptive analysis of changes from baseline to follow-up, (2) correlational analysis of the relationship between participation in MSP activities and changes from baseline to follow-up, and (3) correlational analysis of the relationship between participation in MSP activities and responses on the follow-up survey for items that were administered only at follow-up. For the teacher survey, the descriptive analysis of change focused on the 798 teachers who responded in both years. For both the teacher and principal surveys, change is reported as the mean difference (MD) between the two observations. This enables the results to be interpreted in the units of the survey scale (usually a 5-point scale). For example, an MD of 0.5 indicates that the mean response on the scale at follow-up was 0.5 points higher on the survey scale than the mean response at baseline. For the correlational analysis of new questions on the follow-up surveys, we analyzed population estimates, in some cases restricting the sample to those respondents who had attended a given MSP activity.

For each analysis, we began with the usual threshold of p-values less than 0.05 as evidence of findings not attributable to chance, but we adjusted this threshold downward due to the vast number of statistical tests performed. We conducted 48 tests comparing baseline to follow-up teacher survey scales and 36 tests comparing baseline to follow-up principal survey scales. For the correlational analyses, we conducted 66 tests on the teacher survey and 28 on the principal survey. We used the Bonferroni correction for each family of tests. Significant findings are indicated with an asterisk (*).

Survey analyses used the participation variables, district leadership participation, and adjusted district-level teacher participation, described in Chapter Four. However, for the teacher survey analyses, we separated district leadership participation into two components: the school level, including participation by such leaders as principals, who are assigned to a specific school, and the district level, including participation by such leaders as superintendents, whose work covers multiple schools. In addition, for the principal survey analyses, we created a school-level variable that includes only participation in principal seminars because that activity was specifically designed for principals and was intended to affect their attitudes and behaviors.

Table 5.1
Principal Survey Scales

Scale	Reliability (α)	
	Math	Science
Scales defined separately for mathematics and science instruction		
Knowledge and comfort supporting teachers in implementing the district math (science) curriculum and state standards (3 items)	0.82	0.85
Views on the importance of instructional methods that emphasize in-depth math (science) conceptual understanding (5 items)	0.77	0.82
Views on the importance of using reform-oriented approaches to math (science) classroom instruction and assessment (8 items)	0.80	0.75
Influence of state and federal policies and standards on math (science) instruction (5 items)	0.80	0.84
Influence of district and school policies and reward structures on effective math (science) instruction (7 items)	0.84	0.89
Influence and availability of instructional resources and importance placed on math (science) instruction (8 items)	0.84	0.86
Views on ways to support math (science) teachers (3 items)	0.89	0.91
Comfort in serving as math (science) instructional leader as opposed to an administrative manager (5 items)	0.84	0.90
Scales common to the mathematics and science surveys		
Frequency of observing classrooms and interacting with teachers and students (7 items)	0.84	
Importance of allocating resources, building learning communities, and focusing on assessments (11 items)	0.94	
Efforts to monitor the impact and involvement of teachers in professional development (5 items)	0.86	
Influence on policies that allow teachers time to engage in professional development (4 items)	0.65	
Influence on policies related to professional days (3 items)	0.93	
District support for school improvement (10 items)	0.90	
District support for high academic standards (10 items)	0.95	
Role of the IU and MSP staff in supporting the MSP (2 items)	0.72	
Impact of MSP activities (9 items)	0.92	
Value of university courses or research-focused professional development attended by the principal (4 items)	0.64	
Value of professional development received through professional associations, mentoring, or peer observation (4 items)	0.58	

Table 5.2
Teacher Survey Scales

Scale	Reliability (α) Math	Reliability (α) Science
Scales from items appearing on both the baseline and follow-up surveys		
Traditional learning activities in math or science (6 items)	0.67	0.67
Reform-oriented learning activities in math or science (6 items)	0.75	0.73
Student problem solving or reasoning skills in math (12 items)	0.92	—
Student demonstration of math procedural skills (4 items)	0.83	—
Student demonstration of scientific habits of mind (9 items)	—	0.91
Student communication of science (6 items)	—	0.81
Assessment activities in math (8 items) or science (5 items)	0.69	0.75
Influence of district, state, and national standards and assessments on teaching (6 items)	0.78	
Influence of student- and parent-related factors (4 items)	0.71	
Comfort and preparedness to teach at the appropriate level using a variety of strategies (6 items)	0.83	0.87
Type of professional development completed (7 items)	0.71	
Relevancy of professional development to teacher and school needs (5 items)	0.89	
Focus of professional development on instructional approaches and individual student learning needs (7 items)	0.88	
Focus of professional development on the district or state curriculum, standards, and assessment data (4 items)	0.84	
Scales from follow-up survey items		
Vision and leadership of principal (3 items)	0.84	0.84
Principal's support for professional development (3 items)	0.81	0.83
Principal's role as an instructional leader in the school (7 items)	0.93	0.94
Teacher views of the atmosphere in the school and support for collaboration and reform (5 items)	0.80	0.83
Informal assessment of student's knowledge (5 items)	0.78	0.83
Importance of instructional methods that emphasize in-depth understanding and inquiry-based learning (6 items)	0.83	0.85
Importance of instructional methods that emphasize in-depth understanding and inquiry-based learning in groups (4 items)	0.83	0.83
Scales from follow-up survey items about the impact of MSP activities (repeated for each activity)		
Impact of the activity on the awareness and understanding of how students think about math or science and of research-based instructional practices (2–3 items)	0.73–0.96	
Impact of the MSP activity on teaching behavior and practices (2–4 items)		

The choice of conducting these analyses at the school level, rather than at the district level, was driven by the observation that there was significant variation across schools within districts, both in demographics and in MSP implementation. Survey sampling was designed to enable analysis at the school level.

Findings Reported by K–12 Educators

The remainder of this chapter discusses teacher and principal survey results and information from IHE qualitative data examining short- and midterm outcomes related to changes in the quality of the educator workforce. We begin with a discussion of principal and teacher impressions of the overall impact of the MSP. This is followed by an examination of principal leadership and support for reform-oriented practices, as well as changes in school- and district-level policies. Next, changes reported by teachers on their instructional influences and activities are documented, including any changes reported in the type or quality of professional development they received or the creation of professional learning communities. Finally, the IHE qualitative data are used to examine the impact of the MSP on the quality of the educator workforce at IHEs.

Overall Impact of the MSP

Baseline and follow-up principal surveys asked about the influence of the MSP *overall* on mathematics and science instructional practices, as well as the impact of *individual* MSP activities on instructional practices. The questions about individual MSP activities formed one scale. Overall, principal opinions on this topic did not change significantly from baseline to follow-up; however, principals who completed the principal seminars reported greater increases than did other principals from baseline to follow-up on both the overall impact of the MSP and a scale measuring the combined impact of individual MSP activities (MD = 0.6* for both). In addition, on the follow-up survey, among principals who reported attending the principal seminars, 80 percent reported that this activity had influenced their views or behaviors as principals.

In the follow-up teacher survey, teachers who participated in MSP activities reported their perceptions of the impact of these activities. Overall, teachers agreed that MSP activities caused them to increase their awareness and understanding of mathematics or science concepts and how students think about math. They also agreed, though not as strongly, that the MSP activities helped them to change their teaching practices and motivated them to seek further information or training. These results are reported by MSP activity in Table 5.3.

Principal Leadership

Both the principal and teacher surveys contain measures of principal leadership characteristics, including attitudes and behaviors of principals and teacher views of the support provided by the principal. In general, both the teacher and principal survey results suggest that principals are exhibiting leadership in terms of creating supportive environments to effect change, though responses related to principals as instructional leaders were not as strongly positive. These results are interesting because, early in the implementation of the MSP, the project's leaders observed that support from the administrative school leaders was important in facilitating changes in K–12 teaching. Recognizing that the principal seminars can be influential in

Table 5.3
Teacher Responses Regarding the Impact of MSP Activities in Which They Participated

	Follow-Up Survey Only			
	Increased Awareness and Understanding of Math/Science Concepts and How Students Think About Math/Science		Helped Me Change My Teaching Practices and Seek Further Information/Training	
Activity	**Math**	**Science**	**Math**	**Science**
Leadership Action Academies	1.86 (0.08)	2.09 (0.08)	2.17 (0.08)	2.17 (0.09)
Teacher Leadership Academies	1.75 (0.05)	1.95 (0.07)	2.16 (0.06)	2.14 (0.06)
On-site academies	1.92 (0.04)	2.21 (0.04)	2.29 (0.04)	2.42 (0.04)
Educator networks	1.86 (0.06)	1.80 (0.06)	2.29 (0.07)	2.18 (0.07)
Content short courses	1.74 (0.11)	1.81 (0.07)	2.09 (0.10)	1.88 (0.07)

NOTE: Responses are based on a 5-point Likert scale (1 = strongly agree, 5 = strongly disagree). Values in the table are means (and standard errors) estimated for the population of all teachers in MSP districts.

gaining this administrative support, the project began requiring principals to attend these seminars as a prerequisite for new districts joining the MSP.

From baseline to follow-up, the principal surveys measured changes in principals' views of the importance of a strong professional learning community and comfort in the role of instructional leader (see Table 5.4). (Note that higher values on these scales are more positive responses, the opposite of those in Table 5.3.) First, on whether developing a professional learning community encourages effective science instruction, principal responses increased on a 5-point scale ranging from "inhibits effective instruction" to "encourages effective instruction" (MD = 0.4*). On a scale of "not comfortable" to "very comfortable," principals reported increases in comfort serving as math instructional leaders, including discussing concrete examples of instructional practices with teachers, observing classrooms, examining student work, and providing feedback on teaching (MD = 0.2*). Significant changes were not observed on any of the other scales.

Questions on the follow-up teacher survey gathered information about the roles of principals as school leaders and spanned three survey scales: principal leadership and vision in creating a supportive environment, principal support for and engagement in professional development, and the principal's role as an instructional leader. Results from these scales are shown in Table 5.5. Teachers generally agreed that principals create a supportive school environment. They also agreed that principals are supportive of teacher professional development.[2] Teachers did not agree as strongly, however, that the principal takes an instructional leadership role, engaging with teachers about teaching practices through observations and feedback.[3]

[2] This scale includes whether the principal actively participates in teacher professional development, provides adequate time for professional development, and provides time for teachers to share information and experiences.

[3] Items in this scale include whether the principal talks to the teacher about his or her instructional practices, observes the teacher's classroom, and examines student work for evidence of learning.

Table 5.4
Principal Responses Regarding Leadership Skills

Principal Survey Scales, Principal Leadership	Baseline Math	Baseline Science	Follow-Up Math	Follow-Up Science
Views on ways to support math (science) teachers (1 = inhibits effective instruction, 5 = encourages effective instruction)	4.11 (0.08)	4.07 (0.06)	4.23 (0.10)	4.46* (0.07)
Comfort in serving as math (science) instructional leader as opposed to an administrative manager (1 = not comfortable, 5 = very comfortable)	4.52 (0.03)	4.55 (0.03)	4.71* (0.03)	4.67 (0.04)
Frequency of activities related to building learning communities, focusing on assessments, and effective use of resources (1 = never, 5 = almost daily)	3.11 (0.05)		2.93 (0.05)	
Frequency of observing classrooms and interacting with teachers and students (1 = never, 5 = almost daily)	3.68 (0.05)		3.58 (0.05)	
Frequency of principal and teacher involvement in planning, presenting, and assessing professional development (1 = never, 5 = always)	3.41 (0.06)		3.40 (0.05)	

NOTE: * indicates significant difference from baseline to follow-up after correcting for multiple-hypothesis testing. Values in table are means (and standard errors) estimated for the population of all principals in MSP districts.

Table 5.5
Teacher Responses Regarding Principal Leadership

Teacher Survey Scales on Follow-Up Survey, Principal Leadership	Math Teachers	Science Teachers
Principal's activities create a supportive environment	2.12 (0.03)	2.07 (0.03)
Principal provides support for teacher professional development	2.23 (0.03)	2.18 (0.04)
Principal takes an instructional leadership role	2.72 (0.03)	2.69 (0.04)

NOTE: Responses are based on a 5-point Likert scale (1 = strongly agree, 5 = strongly disagree). Values in the table are means (and standard errors) estimated for the population of all teachers in MSP districts.

District and School Policies and Practices

Another midterm MSP outcome focuses on changes in district and school policies and practices. The principal survey inquired about the potential impact of the MSP on policies and practices (see Table 5.6). Of these scales, only two showed significant change from baseline to follow-up. Principal responses increased on a scale probing whether instructional resources encourage effective instruction in math and science (math MD = 0.2*; science MD = 0.5*).[4] Principal responses also increased on a scale asking whether district and school policies encourage effective science instruction (MD = 0.5*); for mathematics instruction, there was not a significant change on this scale.

Awareness and Knowledge of Research-Based Instructional Practices and Materials

The follow-up teacher survey asked whether a variety of reform-oriented practices are important for effective teaching, such as allowing students time to puzzle through problems, inviting

[4] Examples of scale items include the importance placed on mathematics or science, access to computers and calculators, and the quality of district-adopted instructional materials.

Table 5.6
Principal Responses Regarding School and District Policies and Practices

	Baseline		Follow-Up	
Survey Scales, District and School Policies and Practices	**Math**	**Science**	**Math**	**Science**
Influence and availability of instructional resources and importance placed on math (science) instruction (1 = inhibits effective instruction, 5 = encourages effective instruction)	4.19 (0.04)	3.81 (0.06)	4.42* (0.04)	4.29* (0.05)
Influence of district and school policies and reward structures on effective math (science) instruction (1 = inhibits effective instruction, 5 = encourages effective instruction)	3.67 (0.13)	3.38 (0.06)	3.93 (0.05)	3.88* (0.06)
Influence on policies that allow teachers time to engage in professional development (1 = no influence, 5 = a great deal of influence)	3.43 (0.08)		3.40 (0.06)	
Influence on policies related to professional days (1 = no influence, 5 = a great deal of influence)	2.95 (0.09)		2.89 (0.08)	
District support for school improvement (1 = strongly disagree, 5 = strongly agree)	3.95 (0.05)		4.03 (0.06)	
District support for high academic standards (1 = not at all, 5 = a great deal)	3.76 (0.05)		3.87 (0.05)	
Influence of state and federal policies and standards on math (science) instruction (1 = inhibits effective instruction, 5 = encourages effective instruction)	3.81 (0.07)	3.48 (0.16)	3.96 (0.06)	3.84 (0.07)

NOTE: * indicates significant difference from baseline to follow-up after correcting for multiple-hypothesis testing. Values in the table are means (and standard errors) estimated for the population of all principals in MSP districts.

students to express their thoughts and ask questions, and observing and listening to students interact. These questions formed three classroom practices scales on which teachers generally reported that the activities are important for effective teaching (Table 5.7).

Participating in the MSP's on-site professional development led by teacher leaders is one of the primary mechanisms for teachers in the MSP to be exposed to reform-oriented practices. On both the baseline and follow-up surveys, teachers reported on aspects of the professional development in which they had participated during the previous two years (see Table 5.8). Math and science teachers reported a significant increase in the frequency that the professional development was relevant to their needs and the needs of their school (math and science MD = 0.1*). Items in this scale inquire about how often the professional development activities in which the teachers participated were designed to support school improvement plans, were consistent with the teachers' own goals for development and their department's plan to improve teaching, were based on what they had learned in previous professional development, and were followed up with activities that built on what they had learned. In addition, at follow-up, math and science teachers reported that the professional development had greater emphasis than at baseline on instructional approaches and individual student learning needs (math and science MD = 0.1*).[5] The changes reported by teachers on both these scales are consistent with MSP activities. For instance, the district LATs are encouraged to develop a district-wide plan,

[5] This scale asks how much emphasis the professional development activities place on such topics as instructional approaches; in-depth study of concepts in math or science; study of how children learn topics, including individual differences in learning and meeting the learning needs of special populations; and classroom assessment.

Table 5.7
Teacher Responses Regarding Classroom Practices

Teacher Survey Scales on Follow-up Survey, Classroom Practices	Math Teachers	Science Teachers
Importance of informal assessments of student's knowledge	1.39 (0.01)	1.46 (0.02)
Importance of instructional methods that emphasize in-depth understanding and inquiry-based learning	1.39 (0.01)	1.40 (0.02)
Importance of instructional methods that emphasize in-depth understanding and inquiry-based learning in groups	1.46 (0.02)	1.39 (0.02)

NOTE: Responses are based on a 5-point scale (1 = very important, 5 = not at all important). Values in the table are means (and standard errors) estimated for the population of all teachers in MSP districts.

Table 5.8
Teacher Responses Regarding Professional Development

	Baseline		Follow-Up	
Teacher Professional Development Survey Scales	Math	Science	Math	Science
Frequency of professional development completed (1 = never, 6 = almost daily)	2.26 (0.05)	2.12 (0.04)	2.16 (0.05)	2.00* (0.04)
Relevancy of professional development to teacher and school needs (1 = never, 4 = often)	2.87 (0.05)	2.72 (0.05)	3.00* (0.05)	2.85* (0.05)
Focus of professional development on instructional approaches and individual student learning needs (1 = none, 4 = great)	2.47 (0.05)	2.24 (0.05)	2.61* (0.05)	2.37* (0.05)
Focus of professional development on the district or state curriculum, standards, and assessment data (1 = none, 4 = great)	2.98 (0.05)	2.54 (0.05)	3.03 (0.05)	2.65 (0.05)

NOTE: * indicates significant difference from baseline to follow-up after correcting for multiple-hypothesis testing. Values in the table are means (and standard errors) estimated for the 798 teachers who responded to both the baseline and follow-up surveys.

and MSP OSAs are designed to build sequentially on the content from previous academies and are intended to focus on reform-oriented instructional approaches, such as those measured by these survey scales.

Creation of Professional Learning Communities

As mentioned earlier, teachers generally agreed that principals create a supportive school environment. The follow-up teacher survey also inquired about teacher views of the atmosphere in the school and support for collaboration and reform. Some of the items on this scale are as follows: support by colleagues to try new ideas, teachers regularly share ideas and materials, and teachers trust each other. The mean response of both math and science teachers on this 5-point scale was between "agree" (2) and "neither agree nor disagree" (3). The mean response for math was 2.47 (standard error = 0.03), and for science 2.54 (standard error = 0.03).

Instructional Practices of K–12 Teachers

An important midterm goal of the MSP on-site professional development and other activities is to improve the teaching practices of math and science teachers. Four scales from the teacher surveys address student learning activities. Each scale includes four to 12 survey items. Although the scales vary slightly for math and science, in both cases, three scales measure active learning and reform-oriented activities and one measures more traditional, passive learning activities. At follow-up, math teachers' responses were significantly different from baseline on two scales, while science teachers' responses were not significantly different on any of the scales (see Table 5.9). The changes in student learning activities reported by math teachers are consistent with greater use of inquiry-based learning practices, as encouraged by the MSP.

Specifically, math teachers reported increases in the amount of time that students spend demonstrating procedural skills, either individually or in pairs or small groups (MD = 0.1*); this includes such activities as students working on problems that take at least 45 minutes to solve and completing proofs. Math teachers also reported decreases in the amount of time that students spend on more traditional types of learning activities (MD = 0.1*), such as watching the teacher demonstrate how to solve a problem, taking notes from lectures or books, completing worksheets, working individually on problems, and taking tests. However, math teachers did not report significant change on a reform-oriented learning activity scale, which includes having the students demonstrate solutions to the class, doing a math activity outside of the classroom, working in pairs or small groups, and using manipulatives, measurement instruments, or data collection devices.

Analysis of the Relationship of MSP Participation to Survey Results

Further analyses were conducted to examine the relationship of educator participation in the MSP to survey responses. Detecting such relationships would provide supportive evidence that the MSP is responsible for the survey response changes reported earlier. For each scale that appeared on both the baseline and follow-up surveys, we examined the correlations between participation and changes on the scale. For scales appearing only on the follow-up surveys, we examined correlations between participation and responses at follow-up. For the principal survey, in addition to actual participation hours, we examined the correlation between whether the principal reported attending principal seminars and changes in the survey scales.

Table 5.9
Teacher Responses Regarding Student Learning Activities

	Baseline		Follow-Up	
Teacher Survey Scales, Student Learning Activities	**Math**	**Science**	**Math**	**Science**
Traditional learning activities in math or science	3.48 (0.04)	2.93 (0.04)	3.37* (0.04)	2.90 (0.04)
Reform-oriented learning activities in math or science	2.84 (0.05)	2.88 (0.06)	2.84 (0.05)	2.94 (0.06)
Student problem solving or reasoning skills in math	3.30 (0.05)		3.38 (0.05)	
Student demonstration of math procedural skills	1.88 (0.06)		2.02* (0.06)	
Student demonstration of scientific habits of mind	3.67 (0.06)		3.67 (0.06)	
Student communication of science	2.72 (0.06)		2.80 (0.06)	

NOTE: * indicates significant difference from baseline to follow-up after correcting for multiple-hypothesis testing. Responses are based on a 6-point scale (1 = none, 6 = almost all of the time). Values in the table are means (and standard errors) estimated for the 798 teachers who responded to both the baseline and follow-up surveys.

In sum, 94 tests were performed and only two revealed a significant relationship. As discussed previously, there were two survey measures on which principals responded differently depending on whether they reported attending principal seminars. One was an item about the overall impact of the MSP, and the other was a scale about the impact of individual MSP activities. In both cases, principals who reported attending the seminars also reported a greater impact on instructional practices in their schools (MD = 0.6* for both). We examined whether these changes in survey measures also showed a significant correlation with hours of participation in principal seminars (rather than principal self-reports of attendance). Those models did not show a significant relationship.

In summary, these analyses were not successful in providing supportive evidence that the MSP is responsible for the survey response changes reported by educators. However, as discussed in Chapter Four, the participation measure is imperfect; for example, it does not consider the engagement of participating educators. It is possible that participation did induce some of the changes observed on the survey scales and that a more refined participation measure would have been more sensitive in detecting this relationship. Future analysis of data from the K–12 case studies may also help to illuminate the survey findings.

Contribution of IHEs to the Quality of the Educator Workforce

The expected contribution of the IHEs to the project's second goal of increasing the quality of the educator workforce can be attained through multiple routes. The primary route is through IHE participation in MSP professional development activities. As a result of participating in expert training sessions and TLAs, IHE faculty members are exposed to the same research-based pedagogy as the K–12 teachers. This experience is intended to lead to changes in IHE instructional practices as STEM and education faculty members incorporate the techniques into their classroom practices. Preservice teachers can then benefit when they take courses from participating STEM and education faculty members. In-service teachers, who participate in TLAs co-facilitated by IHE faculty, are also exposed to both content expertise and improved pedagogy. A secondary route for IHEs to influence the quality of the educator workforce is through the content short courses. K–12 teachers attend in-depth courses on mathematics or science topics taught by IHE faculty, which may increase their knowledge and confidence in teaching these topics. Finally, the TF program is another route that is expected to increase the quality of the educator workforce by providing K–12 teachers with immersion in the higher education environment. TFs spend a sabbatical on an IHE campus and participate in coursework as well as assist a faculty member in the revision of one of the faculty member's courses. Not only do the participants benefit from their experiences as fellows, but after returning to their school districts, they can share their experiences and act as resources for other teachers.

The following sections examine some of the contributions of IHEs to the quality of the educator workforce. The discussion is based on qualitative analysis of IHE data, which is described in detail in Appendix C.

Classroom Instructional Practices at IHEs

Over the three-year period during which we collected data from IHEs, we interviewed 28 of the approximately 55 STEM faculty members who were actively involved in the MSP. Some were interviewed multiple times. Overall, the majority of the faculty interviewed reported changes in instructional practices. Although there was a wide range of descriptions of the types of changes in instructional practices, the changes appeared to focus on increasing the emphasis on student-centered learning, which included group-oriented classroom activities and problem solving in class, and allowing time for students to pursue alternative approaches. In addition, increasing pedagogical awareness appeared to be one primary factor that contributed to these changes in instructional practices. Each of these areas is explored in greater detail next.

Greater Emphasis on Student-Centered Learning. A number of IHE faculty reported altering their instruction to be more student-centered. For example, one IHE mathematics faculty member said, "[The MSP] helped me change the focus from teaching to student involvement . . . a more student-centered approach to teaching." Similarly, an IHE science faculty member said, "In thermodynamics, I'm much more likely to have the students solving problems in teams than solving them on the board. Four years ago, I would never have them solve the problem. I let them make mistakes and have classmates correct them." There are indications suggesting that the shift toward student-centered instruction has had positive effects on students. IHE faculty members reported, "I am getting better-quality answers back from students," "[I] get students to think," and "The students understand."

Classroom observations enabled additional insight into the types of student-centered activities used by faculty members. In year 4, we observed one class from each of the IHEs. Although not meant to be representative, these four classroom observations provide practical examples of how MSP-promoted practices were used in IHE classes. In many cases, IHE faculty members stated that these practices represented a departure from how they typically engage their students.

Group work was described as one of the more common MSP-promoted practices, both in interviews with faculty members and in classroom observations. Three of the four classes observed used small-group discussion during class time. In one class, small-group discussion was the predominant classroom activity, occupying 60 percent of class time. Small-group discussion is defined as activities in which two or more students form groups and engage in conversation with each other about specific subject matter. Despite the common use of this instructional practice, we observed that its purpose varied across classes. In one class, small-group discussion was used to provide an opportunity for students to discuss societal implications of scientific knowledge, whereas in another class, it was used to prepare classroom projects. In the classes we observed, student groups were self-selected. When asked to comment on the effectiveness of student grouping, almost all faculty members reported struggling with whether to allow students to self-select into groups or to designate the grouping. They expressed concern about whether all students benefited from the strategy, particularly when groups bring together students who are not equally motivated.

Increased Pedagogical Awareness. Some of the changes in instructional practices appear to be linked to, or a result of, increased awareness of teaching practices. As one faculty member explained, "Being involved in the MSP has focused faculty on elementary and secondary education. Consequently, attitudes, understanding, and interest in educational aspects have increased." One faculty member explained that her participation in the MSP caused her to be "thinking about teaching all the time." Additionally, some faculty members reported increased awareness of nationally recognized best practices: "I'm more aware of best practices at the national level. I realize [that we] are not alone in facing these challenges, and we can be part of a national solution to these issues, which is rewarding."

Faculty members also reported that their participation in the MSP increased their awareness of the cognitive development of their students. For example, one faculty member said, "I can understand my students' learning better. I am more aware of the education theory behind things." Similarly, another faculty member reported, "Overall, the way it's impacted my teaching is an awareness of different learning styles." Increased awareness in cognitive development, best practices, and pedagogy are important, as these may be associated with changes in instructional practices, particularly in instances in which this awareness may have been limited prior to the MSP.

This increase in pedagogical awareness varied among the STEM and education faculty. For STEM faculty, we noted both increased awareness of education theory that supports instructional practices and increased knowledge of innovative practices that exist for teaching science and math. Education faculty members reported benefits from increased conversation about pedagogy with STEM colleagues who are more attuned to the national importance of these topics. For example, one education faculty member said, "The biggest benefit for me is that people come right here; we can be the hosts of a lot of these things, and we get the benefit of materials and experts in the field. These are benefits for both me and the institution." Another reported,

> I never thought I'd be interacting with content faculty. This process has gone through growing curves. I am now in constant contact with the math department and with science instructors. I meet with math instructors weekly. Partnering with other schools [in math and science] wouldn't have happened otherwise.

Another education faculty member reported that increased collaboration and communication with faculty in the mathematics department showed her that "my math methods are somewhat effective, [and] now I can see how I can improve them."

Ultimately, it appeared that benefits accrued to both STEM and education faculty members through their MSP-induced collaborations: STEM faculty members gained awareness of instructional practices, and education faculty members received greater insight into the perspectives of content experts.

Practices Related to Student-Teacher Placements

One of the goals of the MSP is to place student teachers from the IHEs with K–12 teachers who have participated in MSP training. Placing student teachers with MSP-participating teachers is intended to afford them opportunities to be mentored on MSP-promoted practices and to be fully supported in their first experiences in implementing them. Student teaching with MSP-participating teachers is expected to improve the quality of the educator workforce by increasing the pipeline of new teachers who are knowledgeable about and comfortable implementing the research-based practices disseminated by the MSP.

Interviews with IHE faculty about student-teacher placement indicated that this is one of the more challenging aspects of the partnership because of the number of variables that influence it—many of which are outside the control of the IHEs. Interview data, particularly from year 2, indicate that the locus of control for student-teacher placement resides primarily with the school districts. As explained by one faculty member, "It's really a question of which schools are willing to take them. It would be ideal to have our students placed in [MSP] schools that we're working with." The willingness on the part of schools to accept student teachers from a particular IHE appears to be governed by complex rules and policies, local school district politics, and competition from IHEs other than those in the MSP. Moreover, the significance of each of these factors varies by districts. As one student-teacher placement coordinator explained, "We're at the mercy of where the districts can put the student teachers. Sometimes they have their own rules; for example, teachers can't have a student teacher for two years in a row in some districts."

Placing student teachers in a particular school district is just the first hurdle, in some instances. Ensuring that they are placed with a specific teacher can be even more difficult. Some faculty members attributed this primarily to the limited authority of the individual IHE:

> We may be able to get our students into a particular school district, but we can't dictate which teacher they are assigned to. If the teachers in the MSP program don't solicit a student teacher, we can't assign one to them. Even if they do request a student teacher, we don't have a say regarding which student teacher they are assigned.

The complexity of matching student teachers with specific teachers in a school is compounded by the difficulty of accessing information on which teachers have participated in the MSP in any given school district. Many student-teacher coordinators acknowledged not knowing which teachers participated in the MSP. In addition to these school-level factors, the preferences of the student teachers themselves also influence the placements. These factors include geographic location, as student teachers often prefer to teach in schools close to where they live; salary levels in the schools, since they are often offered permanent jobs in schools in which they were student teachers; and whether the school is in a district that seems likely to be hiring the following year.

Given the number of variables that influence student teacher placement, it is not surprising that many faculty members emphasized the importance of developing personal relationships with the districts as part of the student-teacher placement process. Faculty members mentioned spending a lot of time developing relationships with the districts, especially with special disciplines, such as math and science, in which it may be more difficult to place student teachers. However, the time invested in developing these contacts appears to be wisely spent, as faculty members found it easier to place students when there were good personal connections. Moreover, having personal contacts gave the IHEs more leverage, as explained by one faculty member: "I had a lot of control because I knew the teachers and had a network of people."

Changes to Student-Teacher Placement Practices. As of year 4, 70 (53 percent) of the elementary and secondary math and science student teachers who were placed in partner districts had been placed with MSP-participating teachers. Year 4 interview data suggests that there have been some positive changes in the policies and practices of student-teacher placement. Overwhelmingly, data from each of the four institutions suggest that there are now explicit, intentional efforts to place student teachers with MSP-participating teachers. As one faculty member explained,

> There is a more extended effort this year to place student teachers with teachers who have participated in MSP activities. Being able to place student teachers with folks who have been in MSP trainings contributes to sustainability. There is more of an effort to complete the cycle and to have student teachers see the methods of teaching they're learning reinforced in the school.

Many other faculty members, deans, and student-teacher placement coordinators echoed this statement, suggesting that this may now be a high priority in student-teacher placement: "We're much more aware of trying to place student teachers in MSP districts and with MSP active teachers. It's a top priority to us."

IHEs used various strategies to identify MSP-participating teachers, such as compiling a list of teachers who had participated in MSP activities in the past or who were currently participating in MSP activities, or interviewing teachers before placing students with them to determine whether they had participated in the MSP and whether they utilized inquiry-based practices in their classrooms. One IHE created a database that included even more information on whether teachers had (1) participated in MSP activities, (2) documented use of inquiry-based practices in their classrooms, (3) expressed willingness to host a student teacher, and (4) received positive reviews from former student teachers. In addition to the efforts of IHEs, the MSP PI sent a letter to the districts emphasizing the importance of placing student teachers with teachers from the MSP leadership cadre. It is expected that these concerted efforts will result in an increase in strategic student placements.

However, some faculty members felt that more needed to be done. For example, one faculty member recommended that school districts develop a policy to ensure that student teachers from the four IHEs will be placed with MSP-participating teachers. However, it may be difficult to institute this policy absent evidence that these placements will ultimately lead to changes in instructional strategies that result in improved learning in math and science. Although many faculty members speculated on the advantages of these placements, it was also acknowledged that it would take a long time to determine whether these placements will make a difference. As one faculty member stated, "It takes more than five years for the culture to change and see if we're really making a difference. MSP needs to be a long-term progression, a continuous process."

Summary of Findings Related to the Quality of the Educator Workforce

This chapter examined data from teacher and principal surveys and IHE qualitative data for evidence of change in midterm outcomes related to the quality of the K–16 educator workforce. There are several limitations to the findings reported in this chapter. First, the available data do not directly measure workforce quality, but instead measure midterm outcomes that may be associated with changes in workforce quality. Moreover, the bulk of evidence comes from self-reports from a sample of participants and thus is subject to common biases associated with such data; for example, if respondents answer survey or interview questions inaccurately or if sampled respondents were not representative. Finally, the measures of participation used to examine links between survey results and MSP activities are imperfect, capturing time participating in activities but not the quality of the activities or the engagement of educators.

Generally, educators at both the K–12 and IHE levels reported changes in leadership and instruction that are consistent with the MSP theory of action. K–12 teachers reported that MSP activities increased their awareness and understanding of math and science concepts and how students think about math and science, and helped them change their teaching practices. They also reported that the professional development in which they participated was more often relevant to their needs and was focused on instructional approaches and individual student learning. Principals reported that the principal seminars influenced their views and behaviors as principals. IHE faculty reported a greater emphasis on student-centered instruction and more awareness of different pedagogical techniques. These findings suggest that the activities of the MSP may be having the intended effect on midterm outcomes associated with increasing the quality of the educator workforce. However, further statistical analyses of the relationship between participation in MSP activities and survey scales tracking key midterm outcomes did not provide evidence that the MSP is responsible for the changes reported by educators. Data from the K–12 case studies may be helpful in interpreting these findings.

CHAPTER SIX

Sustainable Partnerships

The third goal of the MSP is to create partnerships that are sustainable and coordinated by the IUs. These partnerships are expected to build intentional feedback loops between the K–12 and IHE levels that tap the discipline-based expertise of IHEs and improve the mathematics and science learning experiences of all K–12 and undergraduate students, including relevant preparation for preservice teachers (Shaneyfelt, 2006–2007). The MSP plans to measure the achievement of this goal by examining the number of IHE courses revised through MSP activities, the sustained involvement of IHE faculty, the placement of student teachers in MSP districts, and the financial sustainability of having the IUs cover the personnel costs of the MSP coordinators. Because the MSP project continues, the extent to which these goals have been achieved is not discussed here. Rather, this chapter focuses on three midterm outcomes associated with the third goal of creating sustainable partnerships—development of partnership, changes in institutional policies and practices, and implementation of challenging courses via the revision of IHE courses.

Partnership Development

Sustained faculty involvement in the MSP will result, in large part, from the development of partnerships among the key players. Yet, current partnership literature, including literature from other Math and Science Partnerships and K–20 partnerships, suggest that very little is understood about partnership development in the public sector and the characteristics and factors that contribute to partnership sustainability (Boyell, 2007; Clifford and Millar, 2008; Halliday, Asthana, and Richardson, 2004; Kingsley and Waschak, 2005; Scherer, 2006; E. Weiss, Anderson, and Lasker, 2002). Even the term *partnership* is defined ambiguously or not at all in much of the literature (Kingsley and Waschak, 2005). As part of our evaluation, we examined the extent to which partnership development occurred within the MSP. Our working premise conceptualized partnership and the process of partnership development as evolving, rather than static. Thus, the first step of our analysis involved operationalizing the terms *partnership* and *partnership development* in order to establish how MSP partners view partnership and determine the extent of partnership development. A review of the MSP and K–20 partnership literature provided a useful taxonomy that conceptualizes partnership in four distinct, though not mutually exclusive, ways (Kingsley and Waschak, 2005):

1. *entity-based*, in which partnerships are conceptualized as comprising memberships, boundaries, and formal and informal organizing structures designed to achieve specific functions
2. *agreement-based*, in which partnerships are conceptualized as a set of predetermined goals aimed at improving performance in STEM education
3. *process-based*, in which partnerships are conceptualized as relationships that are built up over time to enhance levels of trust and cooperation
4. *venue-based*, in which partnerships are conceptualized as simply an opportunity to interact.

We used this taxonomy of partnership conceptualizations to categorize faculty members' definitions of *partnership*.

Similarly, we examined the partnership literature to identify relational features that indicate the development of partnership. A literature review by Clifford and Millar (2008) identified 62 factors associated with partnership success. Some of the most frequently cited factors included open communication, joint work and resource exchange, goal focus, and trust and respect among partners. We used this list of factors to identify and code comments from IHE faculty interviews that are indicative of *partnership development*.

Some key findings emerged from our analysis: (1) the majority of IHE faculty members have process-based conceptualizations of partnership; (2) partnerships appear to have developed between IHE and K–12 educators, between IHEs, and between departments within IHEs; and (3) there appears to be significant variation in the strength of the partnerships. Each of these findings is discussed in detail next.

Conceptualizations of Partnership

Our initial analysis sought to determine how well Kingsley and Waschak's (2005) MSP partnership taxonomy could be applied to IHE faculty members' conceptualizations of partnership. After coding faculty member responses to questions about the meaning of *partnership*, we found that a majority of responses fit within the taxonomy.[1] Approximately 83 percent of faculty interviewees responded with process-based conceptualizations, in which partnerships are conceptualized as relationships built up over time to enhance levels of trust and cooperation. For example, a faculty member with a dual appointment in education and science said, "[A partnership is a] network and resource sharing; letting the teachers know who they can go to and rely on for professional development opportunities."

Roughly 12 percent of IHE faculty members reported venue-based conceptualizations in which partnership is considered an opportunity for interaction. This is represented in the following comment: "It means now you know some people in high schools; if they have a problem they might call you, or . . . you might call them."

Interestingly, none of the IHE faculty members in our sample conceptualized partnership as agreement-based or as entity-based. This differs from the Kingsley and Waschak study (2005), which found that nearly one-third of their respondents described conceptualizations of partnership that were agreement-based, while most of the remaining two-thirds described conceptualizations that were process-based. These differences may be due in part to the selec-

[1] These partnership conceptualizations are not mutually exclusive, and indeed, several IHE faculty members had responses that appeared to fit with more than one conceptualization of partnership. In those cases, we coded the response in both categories.

tion criteria we used in analyzing IHE faculty member interviews. Our analysis used the most recent interview for each person, with the majority of these conducted in year 3. It seems plausible that partnership conceptualizations develop and change over time, starting with a conceptualization of partnership as a formalized agreement and eventually maturing into a process-based conceptualization. Thus, an interesting avenue to explore as the project draws to a close is whether the majority of IHE faculty members' conceptualizations become process-based by the end of the project.

Finally, about 10 percent of faculty members either did not answer the question or their responses were not directly related to the meaning of *partnership*. For example, a response of one IHE faculty member appeared to be more of a suggestion about how the MSP could be improved rather than a statement on the meaning of partnership: "Faculty should go into K–12 classrooms . . . so that they can see what K–12 education looks like." This comment—though not without value—addresses another feature of partnership, not its meaning. Although we searched the entire length of these IHE faculty interviews, we were unable to determine which conceptualizations of partnership the faculty members held.

Partnership Development Between K–12 and IHEs

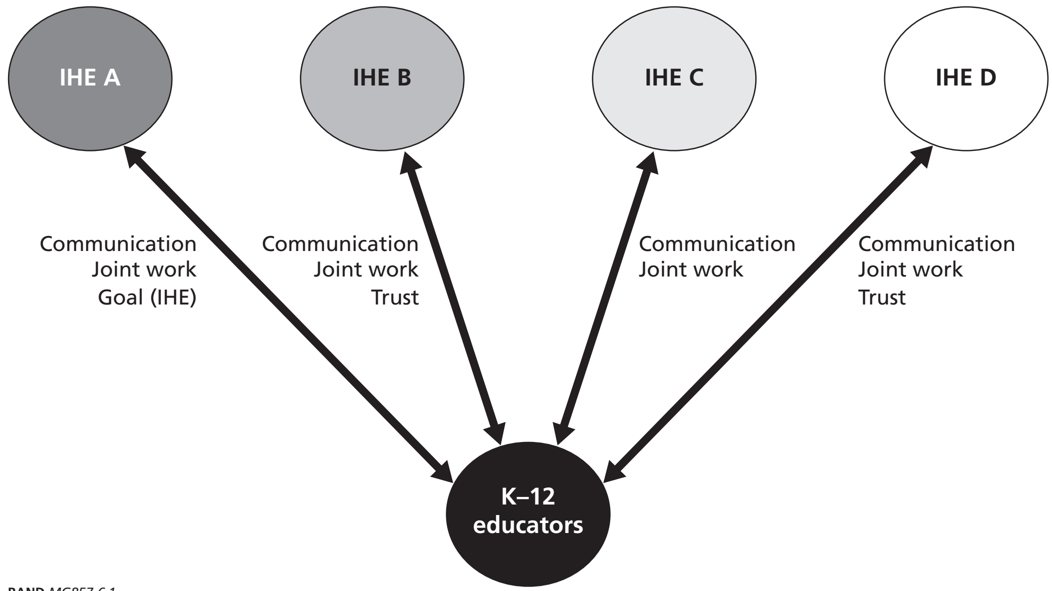
Analysis of partnership development between IHE and K–12 educators, among institutions, and among departments within institutions was based on faculty members' descriptions of their interactions with other partners and whether these descriptions included factors thought to contribute to successful partnerships as referenced in the existing literature (e.g., open communication, joint work and resource exchange, goal focus, trust and respect among partners). We assumed that partnership development was present if any one of these factors were described in the interview data. In some cases, the factors were mentioned verbatim, and in other cases, similar words or phrases were used by the IHE faculty members; for example,

- open communication: talking, contact, email, interactions, sharing
- joint work and resource exchange: learning, collaboration, MSP work
- goal focus: common goals, shared educational ideals, objectives
- trust and respect among partners: admiration, comfort, one of us.

The interview data suggest that partnerships developed between IHE and K–12 educators, between IHEs, and between departments within IHEs. Figure 6.1 illustrates several aspects of these partnerships. In this figure and those in the following sections, we use the following notations:

1. Bidirectional arrows represent instances in which there were reciprocal descriptions of partnership between IHE and K–12 educators who had participated in the TF program.
2. The text to the left of each arrow lists the partnership indicators used by both IHE and K–12 educators to characterize the relationship. Except where noted, members of both the K–12 and IHE partners mentioned the indicator.
3. The thickness of the arrow means that at least three K–12 educators and at least three educators at each of the IHEs used the partnership indicators in characterizing their relationship. Because the number of interviews varied from eight to 14 per IHE, this represented a significant percentage in some cases.

Figure 6.1
Partnership Development Between IHE Faculty and K–12 Educators Who Participated in the Teacher Fellow Program



RAND *MG857-6.1*

All the IHE and K–12 educators we interviewed referred to open communication and joint work in describing their interactions with each other. Additionally, *trust* was used by educators to describe the relationships between K–12 institutions and two of the IHEs, and *common goals* was used by educators to describe the relationship between K–12 institutions and one IHE. We also hypothesize several indicators of the strength and stability of the relationships between partners. One of these is whether the description of partnership is reciprocal. If both entities describe partnership interaction in particular terms, it is likely to be mutually reinforcing. A second indicator is whether descriptions of partnership interactions incorporate multiple factors (e.g., communication, joint work). Finally, a third indicator is whether descriptors of partnership development were reported by multiple individuals at a given institution. All of these hypothesized indicators of partnership strength and stability were observed. Thus, we conclude that the partnership development between IHE and K–12 educators seems stable and strong.

A limitation of these findings is the select group of K–12 educators in our sample: those who had participated in the TF program. This is one of the more intensive MSP activities, in which IHE faculty and K–12 teachers work together for at least one semester, and in some cases as long as a year. Moreover, in addition to their participation in the TF program, these K–12 teachers also interacted with IHE faculty in other MSP activities, such as the TLAs. Thus, K–12 educators who had participated in the TF program may have developed partnerships with IHE faculty that are not representative of partnership development between IHE faculty and non-TF K–12 educators. On the other hand, partnership development between IHE faculty and non-TF K–12 educators could be equally strong because other MSP activities also attempt to foster this type of partnership. By virtue of our restricted sample, we cannot assess the partnership that may have developed between K–12 educators and IHE faculty through these other activities.

Partnership Development Across IHEs

We also found evidence of partnership development between faculty members of different IHEs. As shown in Figure 6.2, most partnership development was reciprocally described (depicted with bidirectional, solid black arrows). However, there are two pairs in which partnership development was described by only one of the partners (IHE B). This is indicated by unidirectional, dashed arrows. The number of IHE faculty members who described partnership development varied across the pairs of institutions. The thickness of the arrowed lines indicates the number of faculty members describing partnership development. The thinnest lines indicate partnership development described by one IHE faculty member; medium-thickness lines indicate partnership development described by two faculty members; and the thickest lines indicate partnership development described by at least three faculty members from each IHE. The text labels in Figure 6.2 show the factors used by faculty members to describe the partnership development. The most frequently described partnership development factor was open communication. *Joint work* was also used to describe partnership development between most pairs of institutions. No faculty members used *common goals* or *trust* to describe partnership development among IHEs.

Partnership Development Across Departments Within IHEs

Partnership also appeared to develop between faculty members in different departments within a given IHE. Although each IHE saw slightly different department-level partnership development, there are several common patterns. Figure 6.3 shows a representative example of department-level partnership development from one IHE. At this IHE, partnership development was described between faculty members in the education and math departments, the education and science departments, and the math and science departments. However, the only

Figure 6.2
Partnership Development Across IHEs

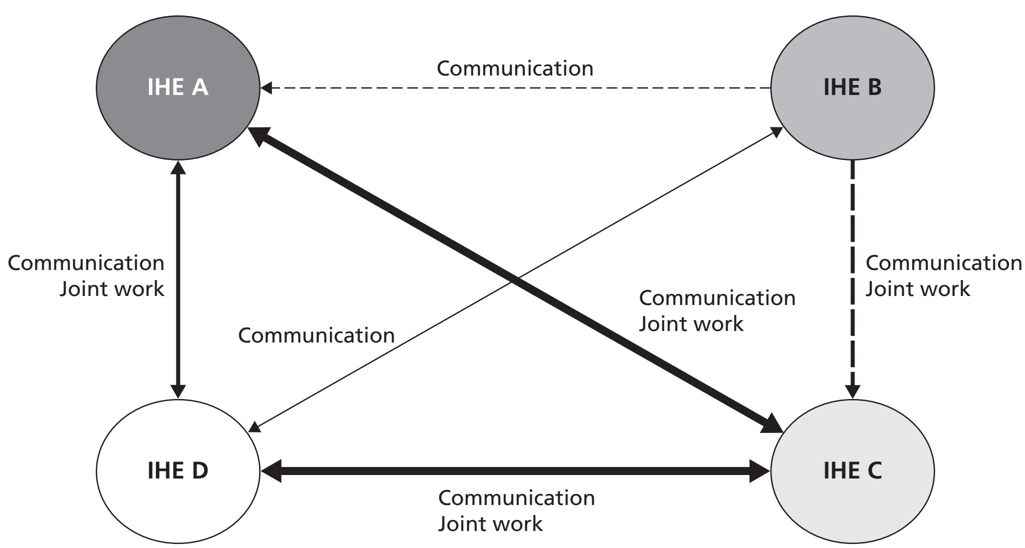


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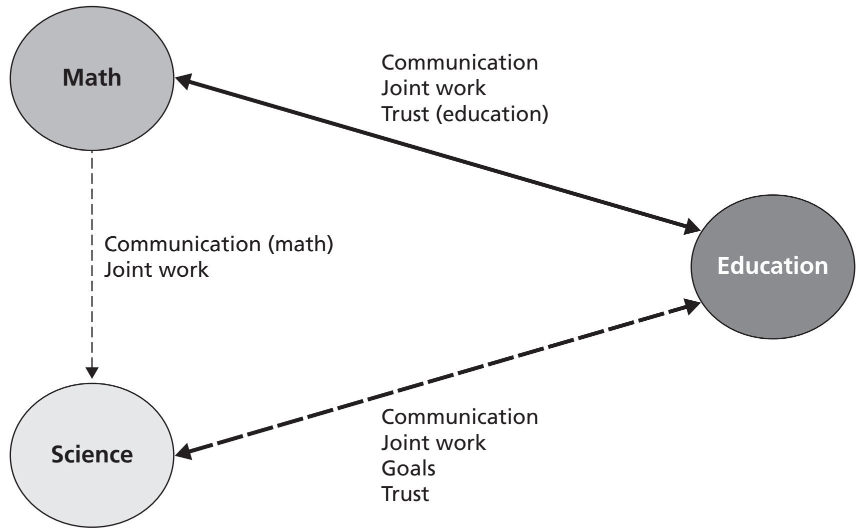
Figure 6.3
Partnership Development Between Departments at One IHE



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one of these that was described reciprocally was between the education and math departments. The others were described in only one direction, indicated by the unidirectional, dashed lines.

Across all IHEs, the education and math departments were the only department pairs in which partnership development was described at every institution; these were described reciprocally in each case (see Table 6.1). Faculty members' impressions of partnership development between math and science departments and science and education departments were either not described at all or were not reciprocally described.

Table 6.1
Patterns of Partnership Development Between IHE Departments

	Departments					
	Math and Science		Math and Education		Science and Education	
IHE	Factors Described	Reciprocal	Factors Described	Reciprocal	Factors Described	Reciprocal
A	Communication Joint work	√	Communication Joint work	√		
B			Communication Joint work	√	Communication Joint work Trust[a]	√
C			Communication Joint work	√	Communication Joint work[a]	√
D	Communication Joint work		Communication Joint work Trust	√	Communication Joint work Goals Trust	

[a] Factor was described by faculty members in the education department only.

Changes in Institutional Policies to Support Sustainability

Sustained MSP participation may be a function not only of the strength of relationships between partners, but also of institutional factors that can support or inhibit partnership. For example, the literature on math and science partnerships indicates that institutions' academic reward systems, leadership, and resources play significant roles in sustained participation (Hora and Millar, 2008; Zhang et al., 2008). This led us to examine the IHE interview data for institutional factors that appeared to be associated with partnership development between institutions in the MSP. Table 6.2 shows the factors that emerged.

This list of factors was drawn primarily from the interview data, rather than being a taxonomy drawn from the literature. As shown in the table, institutional factors, such as academic reward systems, campus initiatives, a history of outreach and collaboration, and supportive leadership, appeared to be contributing factors. Conversely, factors that appeared to inhibit partnership included unsupportive academic reward systems and such external factors as individuals' health problems, faculty or administrative turnover, and limited resources, such as time or finances. Among these factors, the academic reward system appears to have the potential to both contribute to and inhibit partnership development and was one of the factors cited most frequently by IHE faculty members. The following section explores academic reward systems to better understand how they vary across institutions and how they may have changed to help enable the sustainment of the MSP partnerships beyond the term of the project's grants.

IHE Academic Reward Systems

Generally, three factors are considered for IHE faculty members seeking promotion or tenure: (1) scholarship and research, (2) teaching and professional development, and (3) service to the institution and community. However, these three factors are not weighted equally in tenure and promotion decisions. Many IHEs, particularly research universities, consider research productivity to be synonymous with success (Boyer Commission, 1998). The focus on research and research products as two of the most valued outcomes of the university system can present challenges to the sustainment of partnerships with the K–12 community (Williams, 2002). In this context, participation in such projects as the MSP is likely to be viewed as service to the institution and community. Information gathered in interviews with IHE deans and department administrators was consistent with this view. Participation in the MSP, without any

Table 6.2
Factors Associated with Partnership Development Between Institutions

Institutional Factor	Contributes to Partnership Development	Inhibits Partnership Development
Academic reward system	√	√
Campus initiatives	√	
History of outreach or collaboration	√	
Leadership	√	
External factors		√
Faculty stability or administrative turnover		√
Resources (including size)		√

additional activities, was considered to be service even at institutions that had relatively broad definitions of scholarship as espoused by Ernest Boyer's (1997) model of scholarship. Boyer proposed an expanded definition of *scholarship* among the professorate that was based on discovery, integration, application, and teaching. Within this framework, he argued that all forms of scholarship should be recognized and rewarded and that this will lead to more personalized and flexible criteria for gaining tenure. Many of the deans and department administrators whom we interviewed described a variety of ways in which MSP participation, in conjunction with other activities, could count toward scholarship. As explained by one dean, "Doing workshops and [teacher leader] academies and working with teacher fellows is service, but presentations at [conferences] is considered scholarship." Another dean clarified the distinction between scholarship and service in this manner:

> Scholarship is defined as when you have taken your service and written or talked about it and shared the experience with others. If I did a content [short course], that would be service. If I wrote an article about how I developed the [course] and how the teachers went back and used that information, that would be scholarship.

Both of these comments suggest that using knowledge and skills drawn from the experience of MSP participation could contribute to scholarship.

On the other hand, some department administrators perceived MSP participation alone as counting for more than just service. IHE faculty interviews suggested that participation in the MSP could (and should) be viewed as teaching and professional development in addition to service. One tenured professor explained, "If a faculty member goes to a seminar, that's evidence of trying to improve teaching. Doing a TLA should be considered the same as that." It was not clear to what extent deans supported this view that MSP participation alone contributes to teaching. One described being open to the idea:

> If a faculty member were to choose to demonstrate in their teaching portfolio for tenure, promotion, or annual merit, they can use methods learned from the MSP. . . . People haven't used that. If you develop courses and curriculum and assessment of objective outcomes and show pre- and post-MSP data, that would be a guarantee of the person's promotion.

Another dean voiced a similar opinion: "I'm willing to make the case that it's also countable as professional development for the faculty member if they become appropriately engaged." These comments suggest that more would be required for MSP participation to be considered teaching or professional development. And yet, MSP participation consumes much time and effort. Participating in workshops and TLAs is time-consuming, and absent clear signals from the administration that it is valued, faculty members expressed concern about the amount of time they should devote to these efforts. Moreover, some faculty members can get credit toward teaching and professional development and service in other, less time-consuming ways. As one faculty member explained,

> Most people can get an A+ rating on teaching and service without participation in the MSP. These are areas that are easy to do well on, but it is research that is the ultimate hurdle.

Although it is true that faculty members are not participating in the MSP to get credit toward tenure and promotion, the time commitment required by the MSP was viewed as costly because it limited the amount of time available to spend on the research activities that are weighted heavily in tenure and promotion decisions. As explained by one midcareer faculty member, “It cuts into time spent on research which would have had tangible benefits.”

Ambiguity associated with how MSP participation will be viewed in tenure and promotion decisions, juxtaposed with the clarity of the value of other activities, created a sense among many interviewees that MSP participation was risky for junior faculty members. For example, in some IHEs, the number of publications was critical for promotion; thus, any time away from writing was viewed as detrimental. When asked about challenges to sustained participation in the MSP, one senior faculty member stated that an important one is “the time issue for faculty who are not tenured. MSP would count to some degree, but it has less of a value for tenure than research. I think if you did it right and make the claim that MSP is helping you to be a better teacher it could work, but it’s a risky thing.”

Changes to IHE Recognition and Reward Policies

As indicated by the comments in the preceding section, changes in recognition and reward policies may be important in sustaining faculty member participation in the MSP. The consensus among those we interviewed was that, at a bare minimum, the reward system should be structured so that MSP participation does not directly or inadvertently count against promotion and tenure.

From the start of the MSP in 2003, there has been considerable effort by deans to forge relationships with one another and articulate their support of the MSP and its sustainability. An example of this is the dean’s dinners, an event held twice per year in which deans of each IHE partner discuss issues related to the MSP and their sustained participation. One outcome of these gatherings was a joint policy statement on the importance of faculty involvement in the MSP, which was issued in 2006 by the chief academic officers of the four IHEs. In this statement, the chief academic officers recognized the NSF’s expectations to “promote institutional and organizational change to sustain partnerships’ promising practices and policies.” This statement affirms that effective (supported by evidence) work by faculty in MSP activities should be included in their applications for advancement or tenure. Yet, the statement respects the individual character of each IHE and does not attempt to define how much the work should count toward the requirements for advancement or tenure. It is significant that this statement puts on record that each IHE, whether through its rank and tenure committee or chief academic officer, has an obligation to carefully review the MSP work described by faculty members in their applications for advancement or tenure (Hipps, 2006–2007).

As a result of these actions, some institutions appear to have made modest progress toward changing their recognition and reward policies to support MSP participation. One dean said,

> My being appointed dean has been very helpful, since I can help to make this kind of activity count for something towards tenure. I’m encouraging the writing up of outcomes and results of MSP activities in education journals. MSP activities are clearly seen as valuable to the college, the students, and the local community.

Faculty members also reported some success in having policies changed so that MSP activities would be considered for teaching and, potentially, scholarship. At one institution, a faculty member reported, “Yes, the rank and tenure issues have changed. The science and math faculty have become a little more comfortable with participation-based research. Changes are occurring on the rank and tenure committee." At this institution, it appears as though MSP activities and work are being incorporated into the academic reward system and that STEM faculty members are engaged in participation-based research on the MSP or their teaching practices.

In the IHEs with less developed partnerships, as indicated by fewer reciprocally described partnerships, an unsupportive academic reward system is commonly described. This suggests that institutions that have not formally changed their reward and recognition policies may need to consider doing so in order to sustain MSP partnerships beyond the grant period. In the past decade, many institutions and accrediting organizations have attempted to implement changes based on Boyer's model of broader scholarship definition. A study by Massey, Wilger, and Colbeck (2000), based on interviews with more than 300 faculty members from a variety of institutions, including research universities, doctoral-granting institutions, and liberal arts colleges, identified certain features of departments that maintain a supportive culture for all forms of scholarship. These include the following:

- Faculty interact frequently, fostering a healthy awareness of and respect for diverse qualities possessed by colleagues.
- There is a sense of generational equity; senior and junior faculty are viewed as equals.
- Faculty value student evaluations and use them periodically to improve curricula and instruction.
- Incentives for research, service, and quality teaching are balanced.

Thus, a balanced focus on all forms of scholarship could be beneficial beyond sustaining the MSP, accruing other benefits to the IHEs, such as improving collegiality and the overall climate.

Informal Rewards for MSP Participation

In addition to their descriptions of formal recognition and reward policies, faculty members also reported receiving informal rewards or recognition for their MSP work. Explaining the benefits of participation in the MSP, one faculty member said, "We got validation for things we were doing and we made changes to other things." Another said, "[The institution administrators] recognize us for it. [Our dean] is good at letting administrators know."

Additionally, faculty members reported that participating in the MSP was important to them as scholars and educators. One said,

> I'm really enjoying it. It fits in with my lifetime goals. The best part of it is that it's long enough to really develop and have long-term results. This has enough depth, enough initial funding, enough soldiers in the army, that I can see it having a lasting effect.

Another reported, "[The MSP is] something exciting and new. It's a valuable and useful thing, and people like to feel valued and useful."

Thus, it appears that in some cases, IHE faculty members are rewarded both formally and informally. Such rewards are likely to motivate their participation in the MSP and may be necessary to sustain partnerships beyond the grant period. Continued participation of faculty members will be important for maintaining the high-quality preparation of preservice teachers.

The next section explores how revisions to IHE courses have affected not only the content of courses for preservice teachers, but also faculty instructional practices.

Implementing Challenging Courses: IHE Course Revisions

In 2001, the state of Pennsylvania mandated that teacher certification programs certify competency to teach the content specified in the K–12 standards. This mandate created an impetus for IHE partners to refine the coursework for preservice teachers to meet these new expectations. One question addressed in the IHE qualitative analyses is how MSP participation influenced these courses, particularly their content. One direct influence on IHE course content is the TF program. As discussed in Chapter Two, the TF program enables two teachers from each district to spend a summer, semester, or academic year at a partner IHE. During each term that they spend as a TF, the teachers work with faculty members to help revise two courses in which preservice teachers enroll. They also take a math or science college course and participate in other MSP activities. Thus, the TF experience is designed to contribute to the preparation of preservice teachers through course revisions, to strengthen the TF's content knowledge in math or science through IHE course enrollment, and to help build partnerships through participation in MSP activities.

The MSP project set a benchmark to revise 131 courses over the course of the project. As of the fifth year, 97 courses had been revised, some at each participating IHE. These have included biology, chemistry, physics, education, computer science, and environmental science courses. We gathered information on the revised courses from individual interviews with faculty members and TFs, from faculty responses on an MSP course-revision questionnaire,[2] and through focus groups with former TFs.

The character of the course revisions varied across the different disciplines. However, they could be generally categorized as activity-based, content-based, or structure-based revisions. Activity-based course revisions appear to be the most common. Because many of the TFs were experienced in leading group and cooperative learning activities, many of the courses were revised to include more group projects and activities to increase student participation. One faculty member remarked that the greatest value of the course-revision process came from a TF's recommendations, based on experience, related to the development of problem-based cooperative learning activities.

Content-based revisions were less common. These involved augmenting the course with additional materials to encompass a wider variety of approaches to presenting the content. For example, one faculty member described revising a mathematics course to incorporate math problem-solving approaches into each class session and to use examples from the Everyday Math curriculum.[3] In other cases, content-based revisions incorporated new material that was targeted directly to future math and science teachers. Some faculty members questioned whether TFs should be expected to help revise the actual material to be taught. As one faculty member explained, "The fellows can help by knowing what the standards are in the secondary schools, what assessment tools are used there. They can't necessarily help with content." Yet, the

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2 Course-revision questionnaires were received for 52 revised courses. Not all of the questionnaires had been received at the writing of this report.

3 Everyday Math is one of the research-based materials promoted by the MSP.

increased curriculum alignment with Pennsylvania state standards was considered important, as it was likely to create a more seamless transition between K–12 curricula and IHE courses. One faculty member describing the course revision stated, "[Now I am] mapping standards to the syllabus and I will emphasize the standards in some cases. I'll try to implement some of the ideas with the standards."

Finally, a number of course revisions were structure-based, focusing on changes to the sequencing of topics to make the course more effective for student learning. For example, one of the course revisions included reorganizing lecture topics to reflect the sequence in a new textbook and the incorporation of new lecture topics in the course.

Despite the variation in the character of the course revisions, faculty members were fairly similar in terms of their expectations about which aspects of the course would be changed as a result of the course revision. More than half of the faculty members who responded to the MSP course-revision questionnaire expected moderate to substantial changes to their in-class activities, whereas approximately half reported "no change" when asked about change related to assessments of learning outside the classroom. The MSP course-revision questionnaire also asked faculty members to describe the likely impact of course revisions on their students' learning experiences. Most responded that they expected their students to be more engaged. As a result of the revisions, such as increased use of cooperative learning or inquiry-based activities, faculty members said that they expect students not only to engage more, but also to take more responsibility for their own learning:

> Students engage this course somewhat differently because they are no longer evaluated purely on the basis of quiz or exam scores. Now a substantial portion—20 percent—of their grade comes from cooperative learning activities, which they appear to enjoy.

In addition, faculty members said that they expect the revisions to create a much richer environment for student learning, enabling students to increase their skills in such areas as communication, presentation, and hypothesis development.

Summary of Findings Related to Sustainable Partnership

Development of sustainable partnerships is an important goal, not just for the MSP but also the national goals of the NSF. Program announcements describing the Math and Science Partnership program suggest that projects should be partnership-driven. This implies that partnership drives the NSF initiative and that both universities and K–12 institutions play important roles (Kingsley and Waschak, 2005). In many ways, the third goal of the MSP, the creation of sustainable partnerships, undergirds the achievement of the other two project goals. The extent to which the MSP has achieved sustainable partnerships is unclear at this stage, but there are positive indications of partnership development between IHE and K–12 educators, between IHEs, and between departments within a given IHE. Moreover, one of the important factors associated with partnership development, the faculty reward systems of IHEs, has shown modest progress toward a broader definition of scholarship. This is viewed as a key requirement for maintaining and sustaining faculty involvement.

An important measure of sustainable partnership is the number of courses that have been revised through the TF program. By year 5, approximately three-fourths of the targeted

131 courses had been revised. Responses by IHE faculty members on course-revision questionnaires support the value of revising courses. In particular, the revisions, along with their own participation in MSP activities, helped faculty members embrace a wider variety of approaches to presenting the material to their students. As a result of these changes, faculty members were optimistic that students would become more engaged in coursework and take responsibility for their own learning. As the MSP continues, following the progress of the impact of course revisions on student learning may become an additional measure for tracking the progress of sustainable partnerships.

CHAPTER SEVEN

Conclusion

This monograph has examined MSP progress toward meeting its three goals of increasing the mathematics and science achievement of K–12 students, increasing the quality of the K–16 educator workforce, and creating sustainable partnerships. Analyses relied on data collected through the MSP's first five years of implementation, from surveys of teachers and principals, qualitative data from participating IHEs, educator participation records, and student achievement. Here, we briefly summarize the findings reported in earlier chapters.

Achievement analyses found that MSP school districts experienced trends of increase in student mathematics and science scores during the course of the project. For mathematics, similar trends were observed throughout Pennsylvania; for science, there was no external reference for comparison. Further analyses examined the relationship between educators' MSP participation and students' math and science achievement. MSP participation measures were developed to account for differences in the potential impact of educators who play a leadership role, as opposed to educators who teach but do not play a leadership role. These measures were then used in three distinct analytic strategies for statistically modeling the relationship between educator participation and student achievement. Results of these analyses showed only a few significant relationships between MSP participation by educators and student math achievement. These significant relationships appeared among many nonsignificant findings and were inconsistent across cohorts and analyses. As a result, they do not enable us to draw any overall conclusions about the effects of the MSP on changes in math or science achievement.

Analyses of K–12 survey and IHE qualitative data examined evidence of change in midterm outcomes related to the quality of the K–16 educator workforce. Generally, educators at both the K–12 and IHE levels reported changes in leadership and instruction that are consistent with the MSP theory of action. K–12 teachers reported that MSP activities increased their awareness and understanding of math and science concepts and how students think about math and science and helped them change their teaching practices. They also reported that the professional development that they received was more often relevant to needs and was focused on instructional approaches and individual student learning. Principals reported that the principal seminars influenced their views and behaviors as principals. IHE faculty reported a greater emphasis on student-centered instruction and more awareness of different pedagogical techniques. These findings suggest that the activities of the MSP may be having the intended effect on midterm outcomes associated with increasing the quality of the educator workforce. However, further statistical analyses of the relationship of participation in MSP activities to survey scales tracking key midterm outcomes did not provide evidence that the MSP is responsible for the changes reported by educators. Data from the K–12 case studies may be helpful in interpreting these findings.

IHE qualitative analyses examined the development of sustainable partnerships in the MSP and found positive indications of partnership development between IHE and K–12 educators, between IHEs, and between departments within IHEs. Moreover, the analyses found modest progress toward a broader definition of scholarship in IHE faculty reward systems, an important factor in partnership development. Participation in MSP activities, along with revisions to IHE courses through the TF program, helped faculty embrace a wider variety of approaches to presenting the material to their students. As a result of these changes, faculty members were optimistic that students would become more engaged in coursework and take responsibility for their own learning.

In sum, the evaluation found numerous indications that changes are occurring that are consistent with the MSP theory of action. Thus, MSP partners appear to be making progress toward the three MSP goals, though attempts to statistically link this progress to MSP participation were not successful. There are several limitations to note. The evaluation was designed to be selective in its data collection and analyses, primarily assessing the project's achievement of its goals and the major pathways toward achieving those goals; the evaluation relies on self-report data from a sample of participants and is subject to common potential biases associated with such data; and, importantly, if the MSP intervention strategies require more than four years to achieve project goals, this evaluation may not detect the impact. This monograph concludes the MSP evaluation activities of RAND Education. Note, however, that it does not constitute a final evaluation of the MSP. The project, including data collection and evaluation activities, is expected to continue through a forecasted end date in 2010.

Achievement Analysis Methods and Results

This appendix contains additional information related to the achievement analyses discussed in Chapter Four.

Student Achievement Analysis Methods

Student-Level Achievement Models

For each cohort analyzed in the student-level achievement models, a multilevel, mixed-effect, cross-classified model was used to predict the post-test scores using the pretest scores, demographic variables (race/ethnicity, gender, and socioeconomic status), and individual-level participation and teaching experience of linked educators in each year as covariates and accounting for the clustering of students within classrooms (Lockwood, et al., 2007; McCaffrey, Lockwood, et al., 2004). The model used for analysis was

$$Y_i = \mu_0 + \lambda^T X^T + \sum_{k=1}^{m} \beta_k P_{ik} + \sum_{k=1}^{m} \theta_k + \sum_{k=1}^{m} \gamma_k E_{ik} + \varepsilon_i,$$

where Y_i denotes student i's standardized post-MSP math achievement score, μ_0 is the overall average math achievement, X^T is a vector of student demographic information and prior math and reading achievement scores, λ^T is a vector of estimated coefficients for the variables included in X^T, k represents the year of MSP, and m refers to the length of MSP exposure for educators linked to a certain cohort of students. The variable m differs across cohorts of students. It is equal to 3 for cohort G (grade 11), 2 for cohort K (grade 7), and 1 for cohorts L (grade 6) and N (grade 4).[1] P_{ik} represents the average of individual-level participation across all educators linked to student i in year k. β_k is the estimated fixed-effect coefficient for educators' participation in year k. θ_k indicates the residual random teacher effect to account for clustering within classrooms in year k. E_{ik} is the average teaching experience across all educators linked to student i in year k. γ_k represents the estimated fixed-effect coefficient for educators' teaching experience in year k. The term ε_i is the residual error term with mean zero and variance σ^2_{ε}. Estimation of these coefficients was implemented in WinBUGS using Markov chain Monte Carlo sampling algorithms (Spiegelhalter, Thomas, and Best, 1999).

[1] Cohorts J and M were not included in the student-level analysis due to the limited number of students linked to educators in all years between pre- and post-MSP math achievement tests.

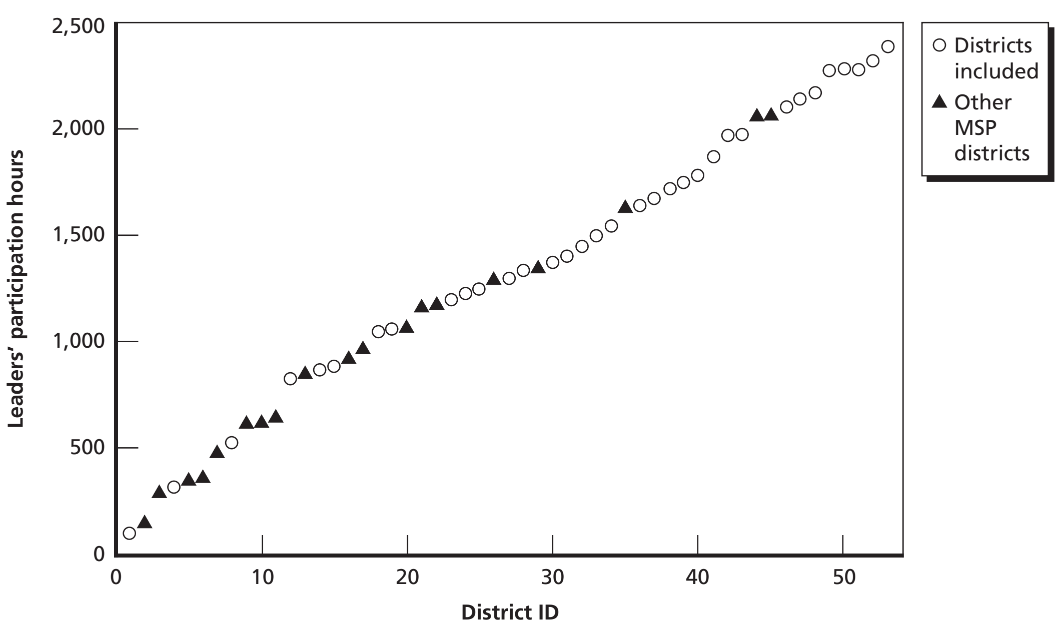
Assumptions underlying this model include the following: (1) when multiple teachers are linked to a student in a single school year, information about the percentage of time a student spent with each of them is not available, so it is assumed that the teachers contributed equally to the student's mathematics achievement, and (2) each teacher's benefit per hour of participation is assumed to be constant. Student-level achievement analyses were conducted only for the mathematics achievement scores because the PROM/SE assessment does not produce comparable student-level scores.

As discussed in Chapter Four, the students, teachers, schools, and districts included in the student-level analyses were constrained by data limitations. Figures A.1 through A.3 show the participation levels of leaders, mathematics teachers, and science teachers, respectively, in the districts that are represented in the student-level analyses. The figures show that all levels of district-level participation are represented. Figures A.4 and A.5 show similar information for the participation of mathematics and science teachers, respectively, in the represented schools. All levels of school-level participation are represented, except for schools with the highest levels of science teacher participation. (As mentioned earlier, these models do not examine science achievement.)

District-Level Achievement Models

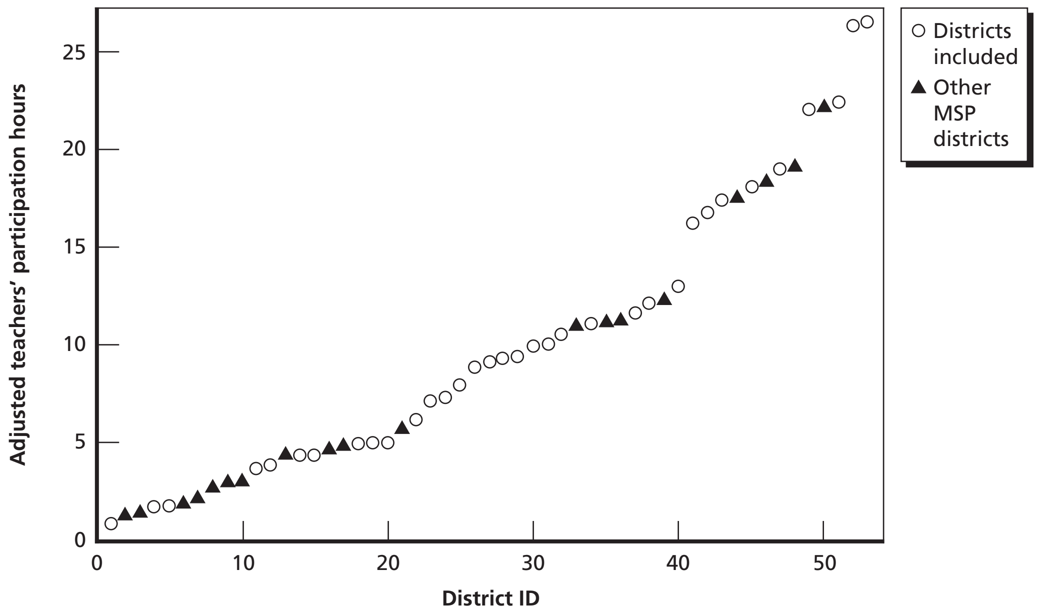
In the district-level achievement analyses, a linear regression model was used to predict district-level aggregated math achievement, controlling for prior district-level aggregated math and reading achievement; the ratios of female, minority, and economically disadvantaged students; district-level leaders' total participation; and adjusted teacher participation. Because leaders'

Figure A.1
Representativeness of Districts Included in Student-Level Models in Terms of Leader Participation



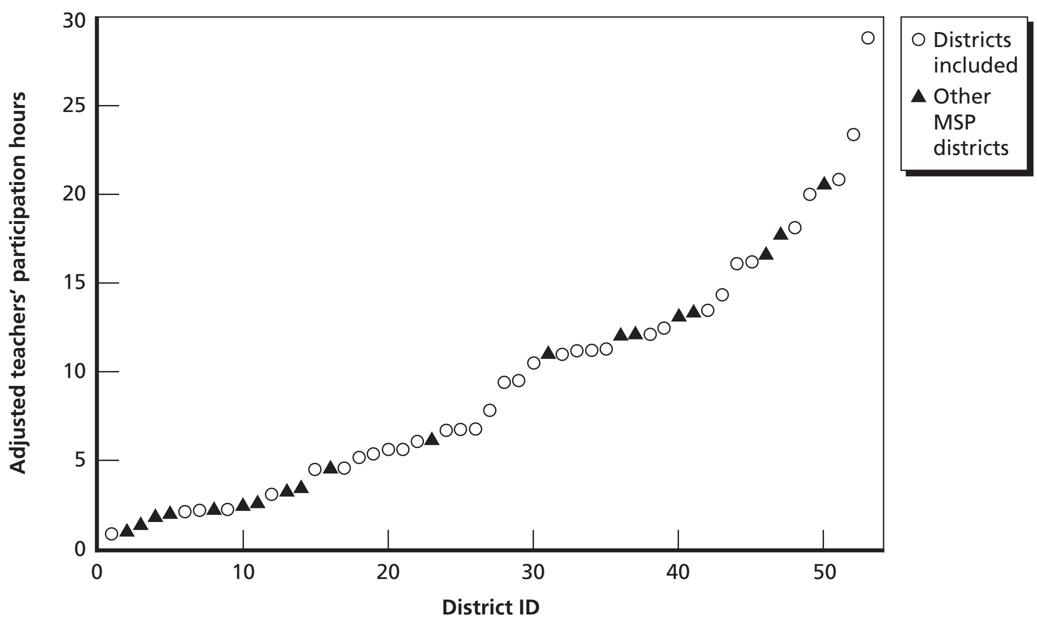
NOTE: Districts are shown in rank order by leaders' participation.
RAND *MG857-A.1*

Figure A.2
Representativeness of Districts Included in Student-Level Models in Terms of Mathematics Teacher Participation



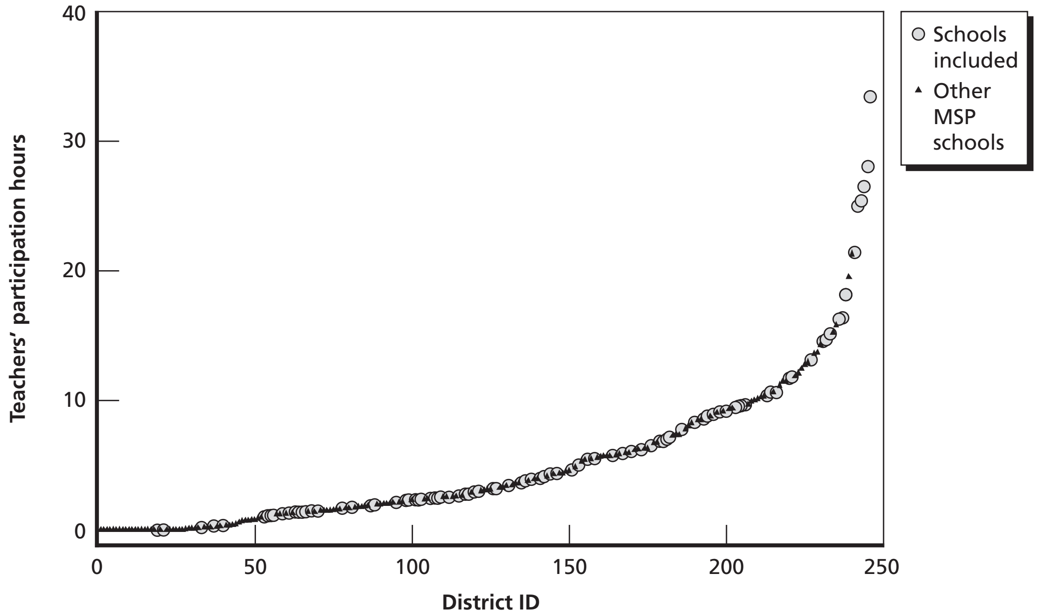
NOTE: Districts are shown in rank order by math teachers' participation.
RAND *MG857-A.2*

Figure A.3
Representativeness of Districts Included in Student-Level Models in Terms of Science Teacher Participation



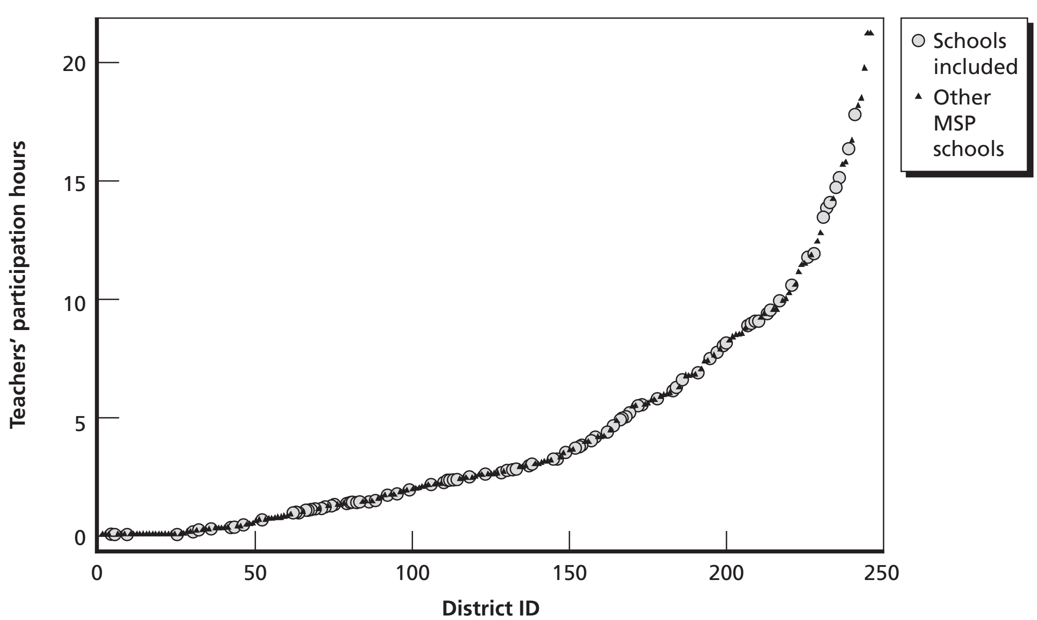
NOTE: Districts are shown in rank order by science teachers' participation.
RAND *MG857-A.3*

Figure A.4
Representativeness of Schools Included in Student-Level Models in Terms of Mathematics Teacher Participation



NOTE: Districts are shown in rank order by math teachers' participation.
RAND *MG857-A.4*

Figure A.5
Representativeness of Schools Included in Student-Level Models in Terms of Science Teacher Participation



NOTE: Districts are shown in rank order by science teachers' participation.
RAND *MG857-A.5*

participation in math and science might affect teaching and learning in both subject areas, the sum of leaders' participation hours in math and science was included in the regression model. Moreover, the adjusted teacher participation in math or science was used in the corresponding regression model. The model used for analysis was as follows:

$$Y_{d-post} = \mu_0 + \lambda^T X^T + \beta_L P_L + \beta_T P_T + \varepsilon,$$

where Y_{d-post} refers to the district-level aggregated achievement score; μ_0 is the overall mean for the district-level aggregated achievement score; X^T is a vector of district-level prior achievement scores and ratios of female, minority, and economically disadvantaged students; λ^T contains estimated coefficients for each component in vector X^T; P_L and P_T are district-level leaders' total participation and adjusted teachers' participation, respectively; β_L and β_T are estimated coefficients for leaders' total participation and adjusted teachers' participation, respectively; and ε is the residual error item with mean zero and variance $\sigma^2{}_{\varepsilon}$.

These district-level achievement analyses were conducted for both mathematics and science achievement scores. For each cohort in the analysis, variables for district-level leaders' total participation and adjusted teachers' participation contain the participation of the corresponding educators from the beginning of MSP implementation up to the year of the post-test. Within the cohorts and districts contributing data to these analyses, the correlation of leaders' and teachers' participation is high—in the range of 0.8 to 0.9. Therefore, the measures were included in models both individually and simultaneously; the results were not sensitive to this choice. For district-level analyses of MSP participation and science achievement for cohorts H and K, students' science achievement scores in 2003–04 were used as covariates in the regression model. For the other four cohorts, students' prior math and reading achievement scores were used because no science pretest score was available. This model was implemented in Stata® version 10 (StataCorp, 2007).

Statewide Comparison-Group Achievement Models

For the statewide achievement models, the three comparison groups described in Chapter Four were formed using the method described by McCaffrey, Ridgeway, and Morral (2004). The method uses weights to reduce pretreatment differences between the MSP and comparison districts. Tables A.37 through A.39, later in this appendix, show the balance in pretreatment covariates before and after matching for the three comparison groups. The propensity weights were calculated in R (R Development Core Team, undated) using the package twang (Ridgeway, McCaffrey, and Morral, 2006).

The analysis uses the percentage of students scoring at the advanced or proficient level on the mathematics PSSA. Separate models were run for each cohort of students for whom PSSA mathematics proficiency levels were available both in 2003–04 or earlier (as a pre-MSP measure) and in 2006–07 (as a post-MSP measure). The model used for analysis was as follows:

$$Y_{d-post} = \mu_0 + \lambda^T X^T + \beta P + \varepsilon,$$

where Y_{d-post} refers to district-level aggregate proficiency levels, μ_0 is the overall mean for district-level aggregated proficiency, X^T is a vector of district-level pre-MSP proficiency levels and variables that were not well balanced in the propensity match, λ^T contains estimated coefficients for each component in vector X^T, and P is district-level value for leaders' total participation or teachers' adjusted participation. Of primary interest is β, the estimated coefficient for participation. ε is the residual error item with mean zero and variance σ^2_{ε}. The models were run separately on the three comparison groups and produced generally consistent results. The models were fit in R using svyglm (from the survey package; see Lumley, 2004), a generalized linear model with inverse-probability weighting and standard errors that account for weighting.

Student-Level Analysis Results for Mathematics

Tables A.1 through A.8 present the student-level results for mathematics for each cohort. In the tables of descriptive statistics, N_s is the number of students and N_t is the number of teachers. All test scores are standardized. Female, minority, individualized education plan (IEP), and disadvantaged students represent the proportions of those students in a district. For each student, teaching experience in a particular school year is the average of teaching experience of all teachers linked to that student in that year; teacher participation in a particular school year is the average of log-transformed participation hours of all teachers linked to that student in that year.

Table A.1
Descriptive Statistics of Variables Included in the Student-Level Mixed-Effect Model Analysis for Mathematics, Cohort G (Grade 11 in 2006–07)

Variable	N_s	N_t	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	1,944		0.00	1.00	–2.57	4.03
Math score in 2003–04	1,944		0.00	1.00	–7.06	4.52
Reading score in 2003–04	1,944		0.00	1.00	–7.16	3.75
Female	1,944		0.49	0.50	0.00	1.00
Minority	1,944		0.07	0.26	0.00	1.00
IEP	1,944		0.05	0.23	0.00	1.00
Disadvantaged students	1,944		0.17	0.37	0.00	1.00
Teaching experience of teachers in 2004–05	1,944	94	13.39	9.68	0.41	36.00
Teaching experience of teachers in 2005–06	1,944	116	11.61	8.51	1.00	37.00
Teaching experience of teachers in 2006–07	1,944	115	10.38	7.10	0.00	35.00
Teacher participation in 2004–05	1,944	94	2.42	1.59	0.00	4.83
Teacher participation in 2005–06	1,944	116	2.98	1.48	0.00	5.36
Teacher participation in 2006–07	1,944	115	3.00	1.69	0.00	5.41

Table A.2
Student-Level Mixed-Effect Model Analysis Results for Mathematics, Cohort G (Grade 11 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		Z	p-value
Math score in 2003–04	0.59	0.02	0.56	0.63	27.65	0.00
Reading score in 2003–04	0.09	0.02	0.06	0.13	5.09	0.00
Female	0.15	0.02	0.11	0.19	6.32	0.00
Minority	–0.04	0.05	–0.12	0.03	–0.91	0.36
IEP	–0.11	0.06	–0.22	–0.01	–1.83	0.07
Disadvantaged students	–0.03	0.03	–0.09	0.02	–0.91	0.37
Teaching experience of teachers in 2004–05	0.00	0.00	0.00	0.01	1.68	0.09
Teaching experience of teachers in 2005–06	0.01	0.00	0.00	0.01	2.52	0.01
Teaching experience of teachers in 2006–07	0.01	0.00	0.00	0.01	2.43	0.02
Teacher participation in 2004–05	–0.01	0.02	–0.04	0.02	–0.36	0.72
Teacher participation in 2005–06	–0.01	0.02	–0.04	0.02	–0.40	0.69
Teacher participation in 2006–07	–0.01	0.02	–0.04	0.02	–0.56	0.57

Table A.3
Descriptive Statistics of Variables Included in the Student-Level Mixed-Effect Model Analysis for Mathematics, Cohort K (Grade 7 in 2006–07)

Variable	N_s	N_t	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	1,978		0.00	1.00	–2.65	4.44
Math score in 2004–05	1,978		0.01	1.00	–3.18	3.91
Reading score in 2004–05	1,978		0.01	1.00	–6.38	2.94
Female	1,978		0.52	0.50	0.00	1.00
Minority	1,978		0.12	0.32	0.00	1.00
IEP	1,978		0.08	0.28	0.00	1.00
Disadvantaged students	1,978		0.32	0.47	0.00	1.00
Teaching experience of teachers in 2005–06	1,978	64	16.42	11.35	1.00	34.00
Teaching experience of teachers in 2006–07	1,978	58	10.76	8.46	0.00	34.00
Teacher participation in 2005–06	1,978	64	3.07	1.33	0.00	5.24
Teacher participation in 2006–07	1,978	58	3.69	1.04	0.00	5.36

Table A.4
Student-Level Mixed-Effect Model Analysis Results for Mathematics, Cohort K (Grade 7 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		Z	p-value
Math score in 2004–05	0.60	0.02	0.57	0.63	33.22	0.00
Reading score in 2004–05	0.13	0.02	0.10	0.16	7.42	0.00
Female	0.00	0.02	–0.04	0.04	0.17	0.87
Minority	0.00	0.05	–0.07	0.08	0.03	0.98
IEP	–0.35	0.05	–0.43	–0.27	–7.04	0.00
Disadvantaged students	–0.10	0.03	–0.15	–0.05	–3.43	0.00
Teaching experience of teachers in 2005–06	0.00	0.00	–0.01	0.00	–0.83	0.40
Teaching experience of teachers in 2006–07	0.00	0.01	–0.01	0.01	–0.33	0.74
Teacher participation in 2005–06	0.07	0.02	0.04	0.10	3.64	0.00
Teacher participation in 2006–07	–0.03	0.04	–0.10	0.03	–0.81	0.42

Table A.5
Descriptive Statistics of Variables Included in the Student-Level Mixed-Effect Model Analysis for Mathematics, Cohort L (Grade 6 in 2006–07)

Variable	N_s	N_t	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	4,105		0.00	1.00	–2.80	4.15
Math score in 2005–06	4,105		0.00	1.00	–3.17	3.67
Reading score in 2005–06	4,105		0.00	1.00	–3.18	4.10
Female	4,105		0.50	0.50	0.00	1.00
Minority	4,105		0.16	0.54	0.00	4.00
IEP	4,105		0.11	0.32	0.00	1.00
Disadvantaged students	4,105		0.27	0.44	0.00	1.00
Teaching experience of teachers in 2006–07	4,105	94	11.23	10.07	0.00	35.00
Teacher participation in 2006–07	4,105	94	2.82	1.32	0.00	5.20

Table A.6
Student-Level Mixed-Effect Model Analysis Results for Mathematics, Cohort L (Grade 6 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		Z	p-value
Math score in 2005–06	0.64	0.01	0.61	0.66	52.86	0.00
Reading score in 2005–06	0.19	0.01	0.16	0.21	14.93	0.00
Female	0.02	0.02	–0.01	0.05	1.33	0.18
Minority	0.02	0.02	–0.01	0.05	1.53	0.13
IEP	–0.08	0.03	–0.14	–0.03	–2.85	0.00
Disadvantaged students	–0.08	0.02	–0.12	–0.04	–3.94	0.00
Teaching experience of teachers in 2006–07	0.00	0.00	0.00	0.01	1.18	0.24
Teacher participation in 2006–07	–0.01	0.01	–0.03	0.02	–0.44	0.66

Table A.7
Descriptive Statistics of Variables Included in the Student-Level Mixed-Effect Model Analysis for Mathematics, Cohort N (Grade 4 in 2006–07)

Variable	N_s	N_t	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	1,842		0.00	1.00	–2.77	4.34
Math score in 2005–06	1,842		0.00	1.00	–3.01	2.41
Reading score in 2005–06	1,842		0.00	1.00	–3.18	2.96
Female	1,842		0.51	0.50	0.00	1.00
Minority	1,842		0.11	0.31	0.00	1.00
IEP	1,842		0.14	0.35	0.00	1.00
Disadvantaged students	1,842		0.30	0.46	0.00	1.00
Teaching experience of teachers in 2006–07	1,842	156	15.19	11.02	0.00	37.00
Teachers' participation in 2006–07	1,842	156	2.66	1.29	0.00	5.28

Table A.8
Student-Level Mixed-Effect Model Analysis Results for Mathematics, Cohort N (Grade 4 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		Z	p-value
Math score in 2005–06	0.50	0.02	0.46	0.53	26.15	0.00
Reading score in 2005–06	0.28	0.02	0.24	0.32	14.12	0.00
Female	0.08	0.03	0.03	0.14	2.85	0.00
Minority	–0.05	0.05	–0.16	0.05	–1.03	0.30
IEP	–0.11	0.04	–0.20	–0.03	–2.56	0.01
Disadvantaged students	–0.12	0.04	–0.19	–0.05	–3.29	0.00
Teaching experience of teachers in 2006–07	0.00	0.00	–0.01	0.00	–0.60	0.55
Teachers' participation in 2006–07	0.03	0.02	0.00	0.07	1.69	0.09

District-Level Analysis Results for Mathematics

Tables A.9 through A.20 present the district-level results for mathematics for each cohort. All test scores are standardized. Female, minority, IEP, and disadvantaged students represent the proportions of those students in a district. Leader participation is the sum over the indicated years of district leadership participation; teacher participation is the sum over the indicated years of adjusted district-level mathematics teacher participation. These measures are described in Chapter Four.

Table A.9
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Mathematics, Cohort G (Grade 11 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	39	–0.06	0.41	–1.17	0.73
Math score in 2003–04	39	–0.07	0.40	–0.96	0.70
Reading score in 2003–04	39	–0.06	0.37	–0.98	0.56
Female	39	0.50	0.05	0.33	0.57
Minority	39	0.16	0.23	0.00	0.82
IEP	39	0.13	0.07	0.03	0.45
Disadvantaged students	39	0.31	0.25	0.01	1.00
Leader participation, 2003–04 to 2006–07	39	1,427	619	92	2,384
Teacher participation, 2003–04 to 2006–07	39	21.63	12.76	1.39	48.60

Table A.10
District-Level Regression Results for Mathematics, Cohort G (Grade 11 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2003–04	0.61	0.16	0.30	0.92	3.84	0.00
Reading score in 2003–04	0.19	0.17	–0.14	0.52	1.14	0.26
Female	–1.39	0.78	–2.93	0.14	–1.78	0.09
Minority	0.27	0.27	–0.26	0.80	1.00	0.33
IEP	–0.29	0.67	–1.60	1.02	–0.43	0.67
Disadvantaged students	–0.71	0.29	–1.29	–0.14	–2.44	0.02
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	–0.52	0.60
Teacher participation, 2003–04 to 2006–07	0.00	0.00	–0.01	0.00	–0.28	0.78

Table A.11
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Mathematics, Cohort J (Grade 8 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	38	–0.04	0.44	–1.10	0.76
Math score in 2003–04	38	0.00	0.38	–1.09	0.62
Reading score in 2003–04	38	–0.01	0.38	–1.23	0.62
Female	38	0.51	0.05	0.40	0.60
Minority	38	0.19	0.26	0.00	0.90
IEP	38	0.14	0.05	0.05	0.31
Disadvantaged students	38	0.40	0.26	0.07	1.00
Leader participation, 2003–04 to 2006–07	38	1,441	621	92	2,384
Teacher participation, 2003–04 to 2006–07	38	21.82	12.87	1.39	48.60

Table A.12
District-Level Regression Results for Mathematics, Cohort J (Grade 8 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2003–04	0.49	0.24	0.02	0.95	2.04	0.05
Reading score in 2003–04	0.03	0.29	–0.53	0.59	0.11	0.91
Female	0.13	0.94	–1.71	1.97	0.14	0.89
Minority	0.21	0.32	–0.41	0.83	0.65	0.52
IEP	–0.54	1.16	–2.81	1.73	–0.47	0.64
Disadvantaged students	–1.11	0.24	–1.57	–0.65	–4.69	0.00
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	0.85	0.40
Teacher participation, 2003–04 to 2006–07	–0.01	0.00	–0.01	0.00	–1.74	0.09

Table A.13
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Mathematics, Cohort K (Grade 7 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	39	–0.08	0.47	–1.21	0.89
Math score in 2004–05	39	0.03	0.32	–0.89	0.71
Reading score in 2004–05	39	–0.01	0.36	–1.16	0.57
Female	39	0.53	0.04	0.46	0.61
Minority	39	0.20	0.26	0.00	0.91
IEP	39	0.15	0.05	0.05	0.29
Disadvantaged students	39	0.41	0.26	0.06	1.00
Leader participation, 2003–04 to 2006–07	39	1,427	619	92	2,384
Teacher participation, 2003–04 to 2006–07	39	21.63	12.76	1.39	48.60

Table A.14
District-Level Regression Results for Mathematics, Cohort K (Grade 7 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2004–05	0.51	0.18	0.16	0.85	2.86	0.01
Reading score in 2004–05	0.03	0.28	–0.51	0.57	0.12	0.91
Female	–0.01	0.80	–1.58	1.55	–0.02	0.99
Minority	–0.04	0.24	–0.52	0.44	–0.15	0.89
IEP	–0.37	0.71	–1.77	1.03	–0.52	0.61
Disadvantaged students	–1.10	0.28	–1.64	–0.56	–3.98	0.00
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	0.58	0.56
Teacher participation, 2003–04 to 2006–07	–0.01	0.00	–0.01	0.00	–1.97	0.06

Table A.15
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Mathematics, Cohort L (Grade 6 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	44	–0.05	0.45	–1.06	1.07
Math score in 2005–06	44	–0.04	0.39	–0.91	0.85
Reading score in 2005–06	44	–0.07	0.41	–1.18	0.53
Female	44	0.51	0.04	0.40	0.63
Minority	44	0.19	0.25	0.00	0.92
IEP	44	0.14	0.04	0.06	0.23
Disadvantaged students	44	0.40	0.25	0.08	1.00
Leader participation, 2003–04 to 2006–07	44	1,425	608	92	2,384
Teacher participation, 2003–04 to 2006–07	44	20.90	12.78	1.39	48.60

Table A.16
District-Level Regression Results for Mathematics, Cohort L (Grade 6 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2005–06	0.52	0.16	0.21	0.84	3.23	0.00
Reading score in 2005–06	–0.33	0.20	–0.72	0.07	–1.60	0.12
Female	1.08	0.92	–0.73	2.88	1.17	0.25
Minority	0.19	0.28	–0.35	0.73	0.70	0.49
IEP	–2.22	1.12	–4.42	–0.03	–1.98	0.06
Disadvantaged students	–1.14	0.25	–1.64	–0.64	–4.50	0.00
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	1.03	0.31
Teacher participation, 2003–04 to 2006–07	0.00	0.00	–0.01	0.01	–0.13	0.90

Table A.17
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Mathematics, Cohort M (Grade 5 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	38	–0.02	0.41	–0.90	0.74
Math score in 2004–05	38	–0.05	0.38	–0.91	0.71
Reading score in 2004–05	38	–0.07	0.40	–1.39	0.56
Female	38	0.52	0.03	0.44	0.59
Minority	38	0.21	0.26	0.00	0.94
IEP	38	0.15	0.06	0.06	0.32
Disadvantaged students	38	0.43	0.27	0.05	1.00
Leader participation, 2003–04 to 2006–07	38	1,422	627	92	2,384
Teacher participation, 2003–04 to 2006–07	38	21.10	12.48	1.39	48.60

Table A.18
District-Level Regression Results for Mathematics, Cohort M (Grade 5 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2004–05	0.43	0.20	0.04	0.82	2.16	0.04
Reading score in 2004–05	0.08	0.26	–0.42	0.59	0.32	0.75
Female	–0.57	1.13	–2.77	1.64	–0.50	0.62
Minority	–0.16	0.26	–0.67	0.34	–0.63	0.53
IEP	–2.74	0.76	–4.24	–1.25	–3.60	0.00
Disadvantaged students	–0.33	0.30	–0.92	0.26	–1.09	0.28
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	1.05	0.30
Teacher participation, 2003–04 to 2006–07	0.00	0.00	–0.01	0.00	–1.36	0.18

Table A.19
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Mathematics, Cohort N (Grade 4 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Math score in 2006–07	44	–0.04	0.39	–1.00	0.68
Math score in 2005–06	44	–0.05	0.35	–0.80	0.66
Reading score in 2005–06	44	–0.05	0.35	–0.87	0.76
Female	44	0.50	0.04	0.39	0.61
Minority	44	0.19	0.25	0.01	1.00
IEP	44	0.15	0.06	0.00	0.26
Disadvantaged students	44	0.40	0.26	0.05	1.00
Leader participation, 2003–04 to 2006–07	44	1,425	608	92	2,384
Teacher participation, 2003–04 to 2006–07	44	20.90	12.78	1.39	48.60

Table A.20
District-Level Regression Results for Mathematics, Cohort N (Grade 4 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2005–06	0.43	0.25	–0.06	0.92	1.70	0.10
Reading score in 2005–06	0.28	0.26	–0.24	0.80	1.05	0.30
Female	0.82	0.85	–0.85	2.48	0.96	0.34
Minority	–0.16	0.25	–0.65	0.33	–0.64	0.52
IEP	–0.46	0.64	–1.71	0.79	–0.72	0.48
Disadvantaged students	–0.11	0.25	–0.59	0.37	–0.44	0.67
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	1.96	0.06
Teacher participation, 2003–04 to 2006–07	0.00	0.00	–0.01	0.01	–0.17	0.87

District-Level Analysis Results for Science

Tables A.21 through A.36 present the district-level results for science for each cohort. All test scores are standardized. Female, minority, IEP, and disadvantaged students represent the proportions of those students in a district. Leader participation is the sum over the indicated years of district leadership participation; teacher participation is the sum over the indicated years of adjusted district-level science teacher participation. These measures are described in Chapter Four.

Table A.21
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort F (Grade 10 in 2004–05)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2004–05	22	–0.07	0.33	–0.95	0.48
Math score in 2002–03	22	–0.02	0.33	–0.62	0.56
Reading score in 2002–03	22	–0.02	0.35	–0.76	0.49
Female	22	0.49	0.04	0.44	0.59
Minority	22	0.16	0.21	0.00	0.68
IEP	22	0.11	0.09	0.00	0.33
Disadvantaged students	22	0.31	0.26	0.00	1.00
Leader participation, 2003–04 to 2004–05	22	765	234	92	1,262
Teacher participation, 2003–04 to 2004–05	22	5.61	3.59	0.80	12.88

Table A.22
District-Level Regression Results for Science, Cohort F (Grade 10 in 2004–05)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2002–03	0.86	0.43	0.02	1.70	2.00	0.07
Reading score in 2002–03	–0.27	0.45	–1.16	0.61	–0.61	0.55
Female	–3.23	1.87	–6.89	0.44	–1.73	0.11
Minority	–0.14	0.33	–0.78	0.50	–0.43	0.68
IEP	0.05	0.45	–0.84	0.94	0.10	0.92
Disadvantaged students	–0.25	0.21	–0.66	0.17	–1.16	0.27
Leader participation, 2003–04 to 2004–05	0.00	0.00	0.00	0.00	–0.46	0.65
Teacher participation, 2003–04 to 2004–05	–0.01	0.01	–0.04	0.01	–1.14	0.28

Table A.23
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort G (Grade 10 in 2005–06)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2005–06	40	–0.09	0.29	–0.86	0.41
Math score in 2003–04	40	0.01	0.38	–0.81	0.75
Reading score in 2003–04	40	0.01	0.35	–0.80	0.61
Female	40	0.50	0.04	0.39	0.61
Minority	40	0.12	0.14	0.00	0.67
IEP	40	0.12	0.16	0.00	1.00
Disadvantaged students	40	0.24	0.17	0.00	0.71
Leader participation, 2003–04 to 2005–06	40	1,137	413	279	1,886
Teacher participation, 2003–04 to 2005–06	40	16.38	9.50	3.17	35.66

Table A.24
District-Level Regression Results for Science, Cohort G (Grade 10 in 2005–06)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2003–04	0.12	0.13	–0.14	0.37	0.91	0.37
Reading score in 2003–04	0.50	0.13	0.23	0.76	3.68	0.00
Female	–0.80	0.54	–1.87	0.26	–1.48	0.15
Minority	0.15	0.17	–0.19	0.48	0.85	0.40
IEP	0.15	0.09	–0.03	0.34	1.66	0.11
Disadvantaged students	–0.55	0.16	–0.86	–0.24	–3.53	0.00
Leader participation, 2003–04 to 2005–06	0.00	0.00	0.00	0.00	–1.04	0.31
Teacher participation, 2003–04 to 2005–06	0.00	0.00	0.00	0.01	0.53	0.60

Table A.25
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort H (Grade 10 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2006–07	35	–0.08	0.33	–0.90	0.58
Science score in 2003–04	35	0.02	0.31	–0.59	0.50
Female	35	0.49	0.05	0.39	0.56
Minority	35	0.16	0.21	0.00	0.84
IEP	35	0.11	0.06	0.00	0.38
Disadvantaged students	35	0.32	0.23	0.03	1.00
Leader participation, 2003–04 to 2006–07	35	1,496	582	340	2,384
Teacher participation, 2003–04 to 2006–07	35	20.62	11.35	3.54	44.05

Table A.26
District-Level Regression Results for Science, Cohort H (Grade 10 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Science score in 2003–04	0.63	0.15	0.34	0.92	4.25	0.00
Female	0.40	0.58	–0.74	1.53	0.68	0.50
Minority	–0.39	0.23	–0.83	0.05	–1.72	0.10
IEP	0.15	0.55	–0.94	1.23	0.26	0.79
Disadvantaged students	–0.35	0.20	–0.74	0.03	–1.79	0.08
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	0.42	0.68
Teacher participation, 2003–04 to 2006–07	0.00	0.00	–0.01	0.01	0.19	0.85

Table A.27
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort I (Grade 7 in 2004–05)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2004–05	31	–0.02	0.33	–0.74	0.54
Math score in 2002–03	31	0.02	0.35	–0.86	0.62
Reading score in 2002–03	31	0.04	0.35	–0.82	0.66
Female	31	0.48	0.04	0.39	0.57
Minority	31	0.17	0.21	0.00	0.71
IEP	31	0.09	0.08	0.00	0.24
Disadvantaged students	31	0.35	0.28	0.00	1.00
Leader participation, 2003–04 to 2004–05	31	685	266	92	1,262
Teacher participation, 2003–04 to 2004–05	31	5.01	3.35	0.80	12.88

Table A.28
District-Level Regression Results for Science, Cohort I (Grade 7 in 2004–05)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2002–03	0.10	0.36	–0.60	0.79	0.28	0.79
Reading score in 2002–03	0.25	0.34	–0.43	0.92	0.71	0.48
Female	0.73	1.17	–1.57	3.03	0.62	0.54
Minority	–0.41	0.32	–1.03	0.22	–1.28	0.21
IEP	0.01	0.53	–1.03	1.06	0.03	0.98
Disadvantaged students	–0.40	0.22	–0.83	0.03	–1.83	0.08
Leader participation, 2003–04 to 2004–05	0.00	0.00	0.00	0.00	0.48	0.64
Teacher participation, 2003–04 to 2004–05	0.01	0.01	–0.02	0.04	0.66	0.51

Table A.29
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort J (Grade 7 in 2005–06)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2005–06	40	–0.08	0.36	–0.89	0.61
Math score in 2003–04	40	0.08	0.37	–1.01	0.76
Reading score in 2003–04	40	0.08	0.32	–0.69	0.68
Female	40	0.49	0.04	0.42	0.60
Minority	40	0.16	0.20	0.00	0.85
IEP	40	0.12	0.15	0.00	1.00
Disadvantaged students	40	0.34	0.21	0.00	0.87
Leader participation, 2003–04 to 2005–06	40	1,137	413	279	1,886
Teacher participation, 2003–04 to 2005–06	40	8.10	4.94	1.36	19.16

Table A.30
District-Level Regression Results for Science, Cohort J (Grade 7 in 2005–06)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2003–04	0.04	0.21	–0.37	0.45	0.19	0.85
Reading score in 2003–04	0.36	0.26	–0.15	0.88	1.39	0.17
Female	–0.14	0.90	–1.91	1.63	–0.16	0.88
Minority	–0.50	0.26	–1.00	0.01	–1.91	0.07
IEP	0.40	0.21	–0.01	0.81	1.91	0.07
Disadvantaged students	–0.69	0.21	–1.10	–0.29	–3.33	0.00
Leader participation, 2003–04 to 2005–06	0.00	0.00	0.00	0.00	–0.21	0.84
Teacher participation, 2003–04 to 2005–06	0.00	0.01	–0.02	0.01	–0.55	0.59

Table A.31
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort K (Grade 7 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2006–07	35	–0.11	0.38	–1.04	0.51
Science score in 2003–04	35	0.00	0.32	–0.72	0.51
Female	35	0.47	0.04	0.41	0.56
Minority	35	0.18	0.22	0.00	0.89
IEP	35	0.14	0.06	0.00	0.30
Disadvantaged students	35	0.36	0.24	0.00	1.00
Leader participation, 2003–04 to 2006–07	35	1,496	582	340	2,384
Teacher participation, 2003–04 to 2006–07	35	10.11	5.99	1.61	26.43

Table A.32
District-Level Regression Results for Science, Cohort K (Grade 7 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Science score in 2003–04	0.89	0.17	0.56	1.22	5.35	0.00
Female	–0.23	0.70	–1.61	1.15	–0.32	0.75
Minority	–0.26	0.23	–0.71	0.19	–1.12	0.27
IEP	–0.18	0.56	–1.28	0.92	–0.32	0.75
Disadvantaged students	–0.14	0.21	–0.56	0.27	–0.67	0.51
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	–0.33	0.75
Teacher participation, 2003–04 to 2006–07	0.00	0.01	–0.01	0.01	–0.25	0.81

Table A.33
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort M (Grade 4 in 2005–06)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2005–06	44	–0.02	0.32	–0.77	0.52
Math score in 2004–05	40	0.17	0.26	–0.51	0.70
Reading score in 2004–05	40	0.10	0.23	–0.45	0.49
Female	44	0.49	0.04	0.44	0.60
Minority	44	0.16	0.19	0.00	0.84
IEP	44	0.16	0.20	0.00	1.00
Disadvantaged students	44	0.34	0.21	0.00	0.85
Leader participation, 2003–04 to 2005–06	53	1,001	480	92	1,886
Teacher participation, 2003–04 to 2005–06	53	6.85	5.03	0.76	19.16

Table A.34
District-Level Regression Results for Science, Cohort M (Grade 4 in 2005–06)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2004–05	0.15	0.25	–0.33	0.63	0.60	0.55
Reading score in 2004–05	0.71	0.30	0.12	1.31	2.35	0.03
Female	–0.05	0.90	–1.81	1.71	–0.06	0.96
Minority	–0.83	0.17	–1.16	–0.50	–4.99	0.00
IEP	0.15	0.13	–0.10	0.40	1.17	0.25
Disadvantaged students	0.03	0.17	–0.31	0.37	0.16	0.87
Leader participation, 2003–04 to 2005–06	0.00	0.00	0.00	0.00	–1.65	0.11
Teacher participation, 2003–04 to 2005–06	–0.01	0.01	–0.02	0.01	–0.78	0.44

Table A.35
Descriptive Statistics of Variables Included in District-Level Regression Analysis for Science, Cohort N (Grade 4 in 2006–07)

Variable	*N*	Mean	Std. Dev.	Min.	Max.
Science score in 2006–07	43	–0.04	0.34	–0.80	0.45
Math score in 2005–06	41	0.15	0.35	–0.79	0.84
Reading score in 2005–06	41	–0.01	0.30	–0.62	0.70
Female	43	0.50	0.04	0.39	0.62
Minority	43	0.16	0.20	0.02	0.80
IEP	43	0.14	0.07	0.00	0.30
Disadvantaged students	43	0.36	0.24	0.00	1.00
Leader participation, 2003–04 to 2006–07	53	1,299	633	92	2,384
Teacher participation, 2003–04 to 2006–07	53	8.74	6.05	0.80	26.43

Table A.36
District-Level Regression Results for Science, Cohort N (Grade 4 in 2006–07)

Variable	Coefficient	Std. Err.	95% Confidence Interval of the Coefficient		t	p-value
Math score in 2005–06	0.06	0.19	–0.32	0.44	0.32	0.75
Reading score in 2005–06	0.54	0.23	0.08	0.99	2.32	0.03
Female	–0.27	0.64	–1.52	0.97	–0.43	0.67
Minority	–0.83	0.19	–1.20	–0.46	–4.42	0.00
IEP	0.15	0.48	–0.79	1.10	0.32	0.75
Disadvantaged students	0.03	0.19	–0.34	0.40	0.16	0.88
Leader participation, 2003–04 to 2006–07	0.00	0.00	0.00	0.00	0.33	0.75
Teacher participation, 2003–04 to 2006–07	0.00	0.01	–0.01	0.01	0.04	0.97

State-Level Analysis Results for Mathematics

Tables A.37 through A.39 show the balance in pretreatment covariates before and after matching for the three comparison groups. Tables A.40 and A.41 present the state-level regression results for mathematics for two cohorts.

Table A.37
Balance in Covariates, Before and After Matching, Comparison Group 1

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
PSSA test score means					
1998 grade 11 reading	1,281	1,299	1,288	–0.28	–0.12
1998 grade 11 math	1,266	1,295	1,273	–0.32	–0.08
1998 grade 8 reading	1,291	1,314	1,298	–0.29	–0.09
1998 grade 8 math	1,289	1,311	1,295	–0.25	–0.06
1998 grade 5 reading	1,310	1,330	1,319	–0.21	–0.10
1998 grade 5 math	1,302	1,320	1,311	–0.24	–0.12
1999 grade 11 reading	1,285	1,301	1,288	–0.20	–0.03
1999 grade 11 math	1,273	1,302	1,286	–0.34	–0.15
1999 grade 8 reading	1,290	1,320	1,305	–0.39	–0.19
1999 grade 8 math	1,287	1,315	1,299	–0.30	–0.13
1999 grade 5 reading	1,317	1,333	1,324	–0.20	–0.09
1999 grade 5 math	1,302	1,319	1,312	–0.21	–0.12
2000 grade 11 reading	1,275	1,302	1,289	–0.39	–0.20
2000 grade 11 math	1,282	1,307	1,291	–0.31	–0.11
2000 grade 8 reading	1,305	1,320	1,309	–0.20	–0.06
2000 grade 8 math	1,299	1,324	1,310	–0.27	–0.12
2000 grade 5 reading	1,314	1,332	1,325	–0.24	–0.15
2000 grade 5 math	1,303	1,325	1,318	–0.25	–0.18
2001 grade 11 reading	1,291	1,306	1,299	–0.21	–0.11
2001 grade 11 math	1,291	1,308	1,294	–0.21	–0.04
2001 grade 8 reading	1,309	1,323	1,311	–0.18	–0.02
2001 grade 8 math	1,302	1,325	1,312	–0.27	–0.12
2001 grade 5 reading	1,316	1,332	1,327	–0.22	–0.15
2001 grade 5 math	1,313	1,328	1,322	–0.19	–0.11
2002 grade 11 reading	1,301	1,328	1,316	–0.34	–0.19
2002 grade 11 math	1,295	1,322	1,311	–0.30	–0.17

Table A.37—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
2002 grade 8 reading	1,315	1,327	1,315	–0.15	–0.01
2002 grade 8 math	1,311	1,330	1,326	–0.22	–0.17
2002 grade 5 reading	1,325	1,339	1,334	–0.17	–0.12
2002 grade 5 math	1,319	1,333	1,330	–0.16	–0.14
2003 grade 11 reading	1,321	1,334	1,322	–0.16	–0.01
2003 grade 11 math	1,314	1,327	1,315	–0.16	–0.02
2003 grade 8 reading	1,337	1,358	1,344	–0.24	–0.07
2003 grade 8 math	1,316	1,336	1,325	–0.22	–0.10
2003 grade 5 reading	1,346	1,358	1,356	–0.13	–0.12
2003 grade 5 math	1,348	1,360	1,362	–0.14	–0.17
2004 grade 11 reading	1,342	1,363	1,352	–0.19	–0.09
2004 grade 11 math	1,321	1,333	1,321	–0.13	0.00
2004 grade 8 reading	1,362	1,386	1,369	–0.25	–0.07
2004 grade 8 math	1,336	1,367	1,356	–0.33	–0.22
2004 grade 5 reading	1,386	1,395	1,388	–0.09	–0.02
2004 grade 5 math	1,395	1,404	1,398	–0.09	–0.02
Median absolute standardized bias—PSSA test score means				0.22	0.11
Time trend in PSSA score, slope					
Grade 11 reading	7.64	7.33	7.52	0.03	0.01
Grade 11 math	8.94	6.28	8.21	0.28	0.08
Grade 8 reading	8.89	6.98	7.48	0.22	0.16
Grade 8 math	6.01	4.87	6.75	0.15	–0.10
Grade 5 reading	5.77	4.47	6.24	0.12	–0.04
Grade 5 math	8.40	6.94	8.97	0.14	–0.06
Median absolute standardized bias—time trend in PSSA score, slope				0.15	0.07
2001 racial distribution of students					
Percentage of black students	0.18	0.04	0.09	0.56	0.36
Percentage of Hispanic students	0.00	0.02	0.03	–8.15	–14.16[a]
Percentage of American Indian students	0.00	0.00	0.00	–0.11	–0.17
Percentage of Asian students	0.01	0.01	0.01	–0.30	–0.30
Percentage of white students	0.81	0.93	0.86	–0.49	–0.23

Table A.37—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Transformed percentage of white students	0.34	–0.10	–0.20	–0.35	–0.20
Percentage low income	37.28	25.67	31.80	0.53	0.25
Overall attendance rate	93.52	94.55	94.06	–0.66	–0.35
Overall attendance rate information is missing	0.06	0.08	0.09	–0.05	–0.12
Graduation total rate	90.08	90.65	89.13	–0.08	–0.08
Median absolute standardized bias—2001 racial distribution of students				0.42	0.24
District population, 2000 census					
Percentage black (population)	0.09	0.03	0.05	0.50	0.32
Percentage white (population)	0.89	0.95	0.92	–0.45	–0.23
Percentage other race (population)	0.02	0.03	0.03	–0.27	–0.87
Percentage urban	0.78	0.57	0.73	0.69	0.16
Percentage unmarried heads of household with children	0.29	0.19	0.24	0.63	0.30
Percentage of female heads of household with children	0.23	0.14	0.19	0.66	0.32
Percentage of men with 0–8 years of education	0.05	0.06	0.05	–0.42	–0.27
Percentage of men with 9–11 years of education	0.08	0.10	0.10	–0.44	–0.44
Percentage of men with 12 years of education	0.42	0.44	0.44	–0.19	–0.11
Percentage of men with 13–15 years of education	0.23	0.20	0.21	0.66	0.46
Percentage of men with 16+ years of education	0.22	0.20	0.21	0.11	0.09
Percentage of women with 0–8 years of education	0.06	0.06	0.06	–0.09	–0.17
Percentage of women with 9–11 years of education	0.09	0.09	0.10	–0.22	–0.41
Percentage of women with 12 years of education	0.45	0.46	0.46	–0.20	–0.12
Percentage of women with 13–15 years of education	0.23	0.21	0.21	0.60	0.53
Percentage of women with 16+ years of education	0.18	0.18	0.18	0.00	0.05
Percentage with 13+ years of education	0.43	0.40	0.40	0.25	0.22
Percentage with 16+ years of education	0.20	0.19	0.19	0.06	0.07

Table A.37—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Percentage with master's degree	0.05	0.05	0.05	–0.01	0.02
Percentage of men not in the labor force	0.34	0.30	0.32	0.55	0.19
Percentage of women not in the labor force	0.48	0.45	0.47	0.62	0.29
Percentage of population age 16+ not in the labor force	0.41	0.38	0.40	0.64	0.26
Percentage of population not working in Pennsylvania	0.03	0.05	0.04	–0.33	–0.11
Percentage under 18	0.23	0.24	0.23	–0.49	–0.18
Percentage over 65	0.19	0.16	0.18	0.69	0.24
Median rent ($)	471	509	497	–0.38	–0.26
Median real estate tax ($)	1,516	1,537	1,526	–0.04	–0.02
Median home value ($)	77,270	98,410	90,730	–0.73	–0.46
Percentage of vacant houses	0.08	0.10	0.09	–0.57	–0.43
Percentage of owner-occupied houses	0.71	0.77	0.72	–0.52	–0.15
1999 median household income ($)	35,810	41,570	39,020	–0.58	–0.32
1999 median family income ($)	44,680	49,420	47,350	–0.41	–0.23
1999 per capita income ($)	19,410	20,040	19,680	–0.11	–0.05
Median absolute standardized bias—district population, 2000 census				0.44	0.23
Population					
Population per square mile	1,844	887	1,585	0.49	0.13
Transformed population per square mile	6.83	5.67	6.42	0.87	0.31
Total district population	18,280	21,170	25,200	–0.26	–0.62
Median absolute standardized bias—population				0.49	0.31
2002 district financial data					
Average daily membership (ADM)	2,555	3,187	3,605	–0.42	–0.69
Transformed ADM	2.04	2.05	2.06	–0.16	–0.36
Percentage of students in families receiving welfare	0.06	0.02	0.04	0.60	0.31
Pupil-teacher ratio	15.20	15.78	15.71	–0.36	–0.32
Personal income tax effort	44.30	44.73	45.88	–0.04	–0.15
Transformed personal income tax effort	3.77	3.76	3.79	0.01	–0.1
Average teacher salary ($)	49,570	49,810	50,570	–0.05	–0.21

Table A.37—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Transformed average teacher salary	10.81	10.81	10.82	–0.02	–0.19
Ratio of district market value to total personal income	0.59	0.55	0.56	0.24	0.20
Ratio of market value to personal income tax effort	24.18	20.17	21.75	0.65	0.39
Transformed ratio of market value to income tax effort	4.88	4.47	4.64	0.69	0.41
Ratio of instructional expense to ADM ($)	5,888	5,708	5,795	0.20	0.10
Transformed ratio of instructional expense to ADM	8.67	8.64	8.65	0.23	0.12
Teacher average years of service	15.97	16.69	16.80	–0.33	–0.38
Median absolute standardized bias—2002 district financial data				0.24	0.26
Interactions					
Interaction: ADM, ratio of market value to income	1,421	1,589	1,930	–0.21	–0.63
Interaction: ADM, tax effort	60,550	67,320	82,210	–0.19	–0.59
Interaction: ADM, pupil-teacher ratio	39,520	51,410	57,670	–0.49	–0.74
Interaction: ADM, population per square mile	4,387,000	4,510,000	8,421,000	–0.02	–0.76
Median absolute standardized bias—interactions				0.20	0.69
Median absolute standardized bias—all covariates				0.25	0.16

NOTE: Comparison group 1 (n = 442 school districts) consists of non-MSP Pennsylvania school districts, excluding Pittsburgh and Philadelphia city school districts and a district with no enrolled students. The MSP group (n = 48 school districts) excludes six MSP districts that did not join the project until 2006.

[a] The standardized bias of this covariate is inflated because there is little variation within the MSP group; using the standard deviation across all districts produces a weighted standardized bias of –0.56.

Table A.38
Balance in Covariates, Before and After Matching, Comparison Group 2

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
PSSA test score means					
1998 grade 11 reading	1,281	1,299	1,287	−0.28	−0.10
1998 grade 11 math	1,266	1,295	1,272	−0.31	−0.07
1998 grade 8 reading	1,291	1,313	1,296	−0.28	−0.06
1998 grade 8 math	1,289	1,310	1,292	−0.24	−0.04
1998 grade 5 reading	1,310	1,329	1,317	−0.20	−0.07
1998 grade 5 math	1,302	1,318	1,308	−0.22	−0.08
1999 grade 11 reading	1,285	1,300	1,284	−0.19	0.01
1999 grade 11 math	1,273	1,301	1,283	−0.33	−0.12
1999 grade 8 reading	1,290	1,319	1,302	−0.38	−0.15
1999 grade 8 math	1,287	1,313	1,296	−0.29	−0.10
1999 grade 5 reading	1,317	1,332	1,322	−0.20	−0.07
1999 grade 5 math	1,302	1,317	1,309	−0.18	−0.08
2000 grade 11 reading	1,275	1,301	1,287	−0.39	−0.18
2000 grade 11 math	1,282	1,306	1,288	−0.30	−0.08
2000 grade 8 reading	1,305	1,319	1,307	−0.19	−0.03
2000 grade 8 math	1,299	1,323	1,307	−0.25	−0.08
2000 grade 5 reading	1,314	1,331	1,323	−0.23	−0.11
2000 grade 5 math	1,303	1,324	1,315	−0.23	−0.14
2001 grade 11 reading	1,291	1,306	1,298	−0.20	−0.09
2001 grade 11 math	1,291	1,308	1,292	−0.20	−0.02
2001 grade 8 reading	1,309	1,322	1,308	−0.17	0.02
2001 grade 8 math	1,302	1,324	1,309	−0.25	−0.08
2001 grade 5 reading	1,316	1,331	1,324	−0.20	−0.10
2001 grade 5 math	1,313	1,326	1,319	−0.16	−0.07
2002 grade 11 reading	1,301	1,327	1,314	−0.34	−0.17
2002 grade 11 math	1,295	1,322	1,309	−0.30	−0.16
2002 grade 8 reading	1,315	1,326	1,313	−0.14	0.02
2002 grade 8 math	1,311	1,329	1,323	−0.20	−0.14
2002 grade 5 reading	1,325	1,337	1,332	−0.15	−0.08
2002 grade 5 math	1,319	1,331	1,327	−0.14	−0.10
2003 grade 11 reading	1,321	1,334	1,321	−0.16	0.01

Table A.38—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
2003 grade 11 math	1,314	1,327	1,313	−0.16	0.01
2003 grade 8 reading	1,337	1,357	1,342	−0.23	−0.06
2003 grade 8 math	1,316	1,335	1,324	−0.21	−0.09
2003 grade 5 reading	1,346	1,356	1,355	−0.12	−0.10
2003 grade 5 math	1,348	1,358	1,360	−0.12	−0.14
2004 grade 11 reading	1,342	1,364	1,351	−0.20	−0.08
2004 grade 11 math	1,321	1,334	1,320	−0.13	0.01
2004 grade 8 reading	1,362	1,385	1,367	−0.25	−0.05
2004 grade 8 math	1,336	1,366	1,355	−0.32	−0.20
2004 grade 5 reading	1,386	1,394	1,386	−0.08	0.00
2004 grade 5 math	1,395	1,403	1,396	−0.07	0.00
Median absolute standardized bias—PSSA test score means				0.20	0.08
Time trend in PSSA score, slope					
Grade 11 reading	7.64	7.44	7.63	0.02	0.00
Grade 11 math	8.94	6.38	8.18	0.27	0.08
Grade 8 reading	8.89	6.97	7.63	0.22	0.14
Grade 8 math	6.01	4.91	6.96	0.14	−0.12
Grade 5 reading	5.77	4.34	6.29	0.13	−0.05
Grade 5 math	8.40	6.92	9.08	0.14	−0.07
Median absolute standardized bias—time trend in PSSA score, slope				0.14	0.08
2001 racial distribution of students					
Percentage of black students	0.18	0.04	0.10	0.58	0.35
Percentage of Hispanic students	0.00	0.02	0.03	−6.63	−12.62[a]
Percentage of American Indian students	0.00	0.00	0.00	−0.09	−0.17
Percentage of Asian students	0.01	0.01	0.01	−0.17	−0.23
Percentage of white students	0.81	0.94	0.86	−0.53	−0.24
Transformed percentage of white students	0.34	−0.08	−0.20	−0.37	−0.20
Percentage low income	37.28	26.07	32.69	0.51	0.21
Overall attendance rate	93.52	94.56	94.05	−0.67	−0.34
Overall attendance rate information is missing	0.06	0.08	0.11	−0.07	−0.19
Graduation total rate	90.08	90.78	89.05	−0.10	0.15

Table A.38—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Median absolute standardized bias—2001 racial distribution of students				0.44	0.22
District population, 2000 census					
Percentage black (population)	0.09	0.02	0.05	0.52	0.31
Percentage white (population)	0.89	0.96	0.92	–0.49	–0.23
Percentage other race (population)	0.02	0.02	0.03	–0.08	–0.75
Percentage urban	0.78	0.54	0.72	0.76	0.18
Percentage unmarried heads of household with children	0.29	0.19	0.25	0.64	0.27
Percentage of female heads of household with children	0.23	0.14	0.19	0.66	0.30
Percentage of men with 0–8 years of education	0.05	0.06	0.06	–0.48	–0.29
Percentage of men with 9–11 years of education	0.08	0.10	0.10	–0.49	–0.51
Percentage of men with 12 years of education	0.42	0.45	0.44	–0.26	–0.16
Percentage of men with 13–15 years of education	0.23	0.20	0.21	0.71	0.50
Percentage of men with 16+ years of education	0.22	0.20	0.20	0.17	0.14
Percentage of women with 0–8 years of education	0.06	0.06	0.06	–0.13	–0.20
Percentage of women with 9–11 years of education	0.09	0.09	0.10	–0.25	–0.45
Percentage of women with 12 years of education	0.45	0.47	0.46	–0.29	–0.19
Percentage of women with 13–15 years of education	0.23	0.21	0.21	0.66	0.57
Percentage of women with 16+ years of education	0.18	0.17	0.17	0.06	0.10
Percentage with 13+ years of education	0.43	0.39	0.39	0.33	0.28
Percentage with 16+ years of education	0.20	0.18	0.18	0.12	0.12
Percentage with master's degree	0.05	0.04	0.04	0.05	0.07
Percentage of men not in the labor force	0.34	0.30	0.33	0.51	0.15
Percentage of women not in the labor force	0.48	0.46	0.47	0.55	0.25
Percentage of population age 16+ not in the labor force	0.41	0.38	0.40	0.58	0.21

Table A.38—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Percentage of population not working in Pennsylvania	0.03	0.05	0.04	−0.28	−0.07
Percentage under 18	0.23	0.24	0.23	−0.48	−0.20
Percentage over 65	0.19	0.16	0.18	0.67	0.25
Median rent ($)	471	496	488	−0.26	−0.17
Median real estate tax ($)	1,516	1,460	1,467	0.10	0.08
Median home value ($)	77,270	95,040	88,160	−0.61	−0.37
Percentage of vacant houses	0.08	0.10	0.10	−0.69	−0.51
Percentage of owner-occupied houses	0.71	0.77	0.72	−0.55	−0.12
1999 median household income ($)	35,810	40,740	38,270	−0.50	−0.25
1999 median family income ($)	44,680	48,400	46,480	−0.32	−0.16
1999 per capita income ($)	19,410	19,640	19,380	−0.04	0.01
Median absolute standardized bias—district population, 2000 census				0.48	0.21
Population					
Population per square mile	1,844	754	1,545	0.56	0.15
Transformed population per square mile	6.83	5.55	6.38	0.96	0.34
Total district population	18,280	19,620	24,030	−0.12	−0.51
Median absolute standardized bias—population				0.56	0.34
2002 district financial data					
Average daily membership (ADM)	2,555	2,979	3,466	−0.28	−0.60
Transformed ADM	2.04	2.04	2.06	−0.07	−0.31
Percentage of students in families receiving welfare	0.06	0.02	0.04	0.61	0.29
Pupil-teacher ratio	15.20	15.78	15.74	−0.36	−0.34
Personal income tax effort	44.30	44.05	45.65	0.02	−0.13
Transformed personal income tax effort	3.77	3.75	3.78	0.07	−0.08
Average teacher salary ($)	49,570	49,170	50,200	0.08	−0.13
Transformed average teacher salary	10.81	10.80	10.82	0.11	−0.11
Ratio of district market value to total personal income	0.59	0.56	0.57	0.18	0.13
Ratio of market value to personal income tax effort	24.18	19.95	21.78	0.69	0.39
Transformed ratio of market value to income tax effort	4.88	4.44	4.64	0.73	0.40

Table A.38—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Ratio of instructional expense to ADM ($)	5,888	5,618	5,736	0.30	0.17
Transformed ratio of instructional expense to ADM	8.67	8.62	8.64	0.32	0.18
Teacher average years of service	15.97	16.79	16.88	–0.38	–0.42
Median absolute standardized bias—2002 district financial data				0.29	0.24
Interactions					
Interaction: ADM, ratio of market value to income	1,421	1,518	1,901	–0.12	–0.59
Interaction: ADM, tax effort	60,550	61,840	79,400	–0.04	–0.52
Interaction: ADM, pupil-teacher ratio	39,520	48,030	55,360	–0.35	–0.65
Interaction: ADM, population per square mile	4,387,000	3,436,000	7,748,000	0.18	–0.63
Median absolute standardized bias—interactions				0.15	0.61
Median absolute standardized bias—all covariates				0.25	0.15

NOTE: Comparison group 2 (n = 412 school districts) consists of non-MSP Pennsylvania school districts, excluding Pittsburgh and Philadelphia city school districts, a district with no enrolled students, and districts that participated in the Philadelphia math and science partnership. The MSP group (n = 48 school districts) excludes six MSP districts that did not join the project until 2006.

[a] The standardized bias of this covariate is inflated because there is little variation within the MSP group; using the standard deviation across all districts produces a weighted standardized bias of –0.50.

Table A.39
Balance in Covariates, Before and After Matching, Comparison Group 3

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
PSSA test score means					
1998 grade 11 reading	1,281	1,298	1,283	–0.26	–0.04
1998 grade 11 math	1,266	1,296	1,268	–0.32	–0.03
1998 grade 8 reading	1,291	1,312	1,289	–0.26	0.02
1998 grade 8 math	1,289	1,309	1,287	–0.23	0.02
1998 grade 5 reading	1,310	1,328	1,315	–0.20	–0.05
1998 grade 5 math	1,302	1,318	1,307	–0.21	–0.07
1999 grade 11 reading	1,285	1,300	1,282	–0.18	0.04
1999 grade 11 math	1,273	1,302	1,282	–0.35	–0.10
1999 grade 8 reading	1,290	1,319	1,298	–0.37	–0.10
1999 grade 8 math	1,287	1,312	1,292	–0.28	–0.05
1999 grade 5 reading	1,317	1,331	1,320	–0.18	–0.04
1999 grade 5 math	1,302	1,315	1,307	–0.17	–0.07
2000 grade 11 reading	1,275	1,303	1,284	–0.41	–0.13
2000 grade 11 math	1,282	1,307	1,286	–0.32	–0.05
2000 grade 8 reading	1,305	1,317	1,303	–0.16	0.02
2000 grade 8 math	1,299	1,323	1,306	–0.25	–0.08
2000 grade 5 reading	1,314	1,329	1,318	–0.20	–0.05
2000 grade 5 math	1,303	1,321	1,311	–0.21	–0.10
2001 grade 11 reading	1,291	1,305	1,292	–0.20	–0.01
2001 grade 11 math	1,291	1,308	1,287	–0.20	0.04
2001 grade 8 reading	1,309	1,322	1,303	–0.16	0.08
2001 grade 8 math	1,302	1,324	1,307	–0.26	–0.06
2001 grade 5 reading	1,316	1,328	1,320	–0.17	–0.05
2001 grade 5 math	1,313	1,324	1,318	–0.14	–0.06
2002 grade 11 reading	1,301	1,329	1,314	–0.36	–0.17
2002 grade 11 math	1,295	1,323	1,310	–0.31	–0.16
2002 grade 8 reading	1,315	1,325	1,309	–0.13	0.06
2002 grade 8 math	1,311	1,329	1,325	–0.21	–0.16
2002 grade 5 reading	1,325	1,336	1,332	–0.13	–0.08
2002 grade 5 math	1,319	1,329	1,329	–0.12	–0.12
2003 grade 11 reading	1,321	1,333	1,314	–0.14	0.09

Table A.39—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
2003 grade 11 math	1,314	1,326	1,309	–0.15	0.05
2003 grade 8 reading	1,337	1,357	1,338	–0.23	–0.01
2003 grade 8 math	1,316	1,335	1,321	–0.22	–0.06
2003 grade 5 reading	1,346	1,356	1,353	–0.11	–0.09
2003 grade 5 math	1,348	1,358	1,360	–0.12	–0.14
2004 grade 11 reading	1,342	1,363	1,346	–0.20	–0.03
2004 grade 11 math	1,321	1,333	1,314	–0.12	0.06
2004 grade 8 reading	1,362	1,385	1,364	–0.24	–0.02
2004 grade 8 math	1,336	1,366	1,352	–0.32	–0.17
2004 grade 5 reading	1,386	1,393	1,379	–0.07	0.07
2004 grade 5 math	1,395	1,402	1,391	–0.06	0.05
Median absolute standardized bias—PSSA test score means				0.20	0.06
Time trend in PSSA score, slope					
Grade 11 reading	7.64	7.47	7.45	0.02	0.02
Grade 11 math	8.94	6.10	8.25	0.30	0.07
Grade 8 reading	8.89	7.14	7.93	0.20	0.11
Grade 8 math	6.01	5.19	7.73	0.11	–0.22
Grade 5 reading	5.77	4.26	6.52	0.14	–0.07
Grade 5 math	8.40	7.05	9.49	0.13	–0.11
Median absolute standardized bias—time trend in PSSA score, slope				0.14	0.09
2001 racial distribution of students					
Percentage of black students	0.18	0.03	0.09	0.59	0.35
Percentage of Hispanic students	0.00	0.02	0.04	–7.31	–16.08[a]
Percentage of American Indian students	0.00	0.00	0.00	–0.11	–0.16
Percentage of Asian students	0.01	0.01	0.01	–0.24	–0.29
Percentage of white students	0.81	0.94	0.86	–0.53	–0.21
Transformed percentage of white students	0.34	–0.09	–0.22	–0.37	–0.18
Percentage low income	37.28	25.65	33.58	0.53	0.17
Overall attendance rate	93.52	94.65	94.04	–0.73	–0.34
Overall attendance rate information is missing	0.06	0.07	0.11	–0.02	–0.20
Graduation total rate	90.08	90.92	89.05	–0.12	0.15

Table A.39—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Median absolute standardized bias—2001 racial distribution of students				0.45	0.21
District population, 2000 census					
Percentage black (population)	0.09	0.02	0.05	0.52	0.30
Percentage white (population)	0.89	0.95	0.91	–0.49	–0.21
Percentage other race (population)	0.02	0.02	0.03	–0.14	–0.97
Percentage urban	0.78	0.52	0.72	0.84	0.18
Percentage unmarried heads of household with children	0.29	0.19	0.26	0.65	0.22
Percentage of female heads of household with children	0.23	0.14	0.20	0.69	0.27
Percentage of men with 0–8 years of education	0.05	0.06	0.06	–0.58	–0.41
Percentage of men with 9–11 years of education	0.08	0.10	0.10	–0.61	–0.73
Percentage of men with 12 years of education	0.42	0.45	0.45	–0.29	–0.24
Percentage of men with 13–15 years of education	0.23	0.20	0.20	0.82	0.66
Percentage of men with 16+ years of education	0.22	0.19	0.19	0.21	0.22
Percentage of women with 0–8 years of education	0.06	0.06	0.06	–0.18	–0.36
Percentage of women with 9–11 years of education	0.09	0.10	0.10	–0.31	–0.63
Percentage of women with 12 years of education	0.45	0.47	0.47	–0.32	–0.27
Percentage of women with 13–15 years of education	0.23	0.21	0.20	0.75	0.77
Percentage of women with 16+ years of education	0.18	0.17	0.16	0.08	0.17
Percentage with 13+ years of education	0.43	0.38	0.38	0.38	0.41
Percentage with 16+ years of education	0.20	0.18	0.18	0.14	0.20
Percentage with master's degree	0.05	0.04	0.04	0.07	0.14
Percentage of men not in the labor force	0.34	0.30	0.33	0.54	0.11
Percentage of women not in the labor force	0.48	0.45	0.47	0.67	0.23
Percentage of population age 16+ not in the labor force	0.41	0.38	0.40	0.66	0.18

Table A.39—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Percentage of population not working in Pennsylvania	0.03	0.05	0.04	–0.34	–0.11
Percentage under 18	0.23	0.24	0.23	–0.54	–0.22
Percentage over 65	0.19	0.16	0.18	0.74	0.23
Median rent ($)	471	500	488	–0.30	–0.18
Median real estate tax ($)	1,516	1,451	1,425	0.11	0.16
Median home value ($)	77,270	97,010	88,120	–0.68	–0.37
Percentage of vacant houses	0.08	0.11	0.10	–0.78	–0.6
Percentage of owner-occupied houses	0.71	0.77	0.72	–0.57	–0.09
1999 median household income ($)	35,810	41,120	37,940	–0.53	–0.21
1999 median family income ($)	44,680	48,620	46,010	–0.34	–0.12
1999 per capita income ($)	19,410	19,610	19,130	–0.04	0.05
Median absolute standardized bias—district population, 2000 census				0.52	0.22
Population					
Population per square mile	1,844	687	1,402	0.59	0.23
Transformed population per square mile	6.83	5.43	6.28	1.06	0.41
Total district population	18,280	19,070	23,700	–0.07	–0.48
Median absolute standardized bias—population				0.59	0.41
2002 district financial data					
Average daily membership (ADM)	2,555	2,899	3,422	–0.23	–0.57
Transformed ADM	2.04	2.04	2.06	–0.02	–0.32
Percentage of students in families receiving welfare	0.06	0.02	0.04	0.63	0.26
Pupil-teacher ratio	15.20	15.70	15.62	–0.31	–0.27
Personal income tax effort	44.30	43.65	45.13	0.06	–0.08
Transformed personal income tax effort	3.77	3.74	3.77	0.10	–0.03
Average teacher salary ($)	49,570	48,820	50,130	0.15	–0.12
Transformed average teacher salary	10.81	10.79	10.81	0.19	–0.09
Ratio of district market value to total personal income	0.59	0.55	0.57	0.20	0.12
Ratio of market value to personal income tax effort	24.18	19.50	21.40	0.76	0.45
Transformed ratio of market value to income tax effort	4.88	4.39	4.60	0.81	0.47

Table A.39—Continued

Covariate	MSP Group Mean	Comparison Group Mean		Standardized Bias	
		Unweighted	Weighted	Unweighted	Weighted
Ratio of instructional expense to ADM ($)	5,888	5,612	5,738	0.30	0.17
Transformed ratio of instructional expense to ADM	8.67	8.62	8.64	0.00	0.19
Teacher average years of service	15.97	16.66	16.91	–0.31	–0.43
Median absolute standardized bias—2002 district financial data				0.22	0.23
Interactions					
Interaction: ADM, ratio of market value to income	1421	1443	1882	–0.03	–0.57
Interaction: ADM, tax effort	60,550	59,010	77,390	0.04	–0.46
Interaction: ADM, pupil-teacher ratio	39,520	46,610	54,600	–0.29	–0.62
Interaction: ADM, population per square mile	4,387,000	3,266,000	7,082,000	0.21	–0.51
Median absolute standardized bias—interactions				0.13	0.54
Median absolute standardized bias—all covariates				0.24	0.16

NOTE: Comparison group 3 (n = 338 school districts) consists of non-MSP Pennsylvania school districts, excluding Pittsburgh and Philadelphia city school districts, a district with no enrolled students, districts that participated in the Philadelphia MSP, and districts that, though not members of the MSP, participated in some MSP activities. The MSP group (n = 48 school districts) excludes six MSP districts that did not join the project until 2006.

[a] The standardized bias of this covariate is inflated because there is little variation within the MSP group; using the standard deviation across all districts produces a weighted standardized bias of –0.64.

Table A.40
State-Level Regression Results for Mathematics, Cohort G (Grade 11 in 2006–07)

	Comparison Group 1				Comparison Group 2				Comparison Group 3			
Variable	Coef.	Std. Err.	t	p-value	Coef.	Std. Err.	t	p-value	Coef.	Std. Err.	t	p-value
Math proficiency levels in 2003–04 (grade 8)	0.63	0.08	8.03	0.00	0.63	0.08	7.64	0.00	0.65	0.08	7.66	0.00
Hispanic percentage of enrollment	–33.6	27.3	–1.23	0.22	–37.7	30.6	–1.23	0.22	–27.6	30.3	–0.91	0.36
Black percentage of enrollment	–8.89	7.52	–1.18	0.24	–8.87	7.98	–1.11	0.27	–7.90	7.96	–0.99	0.32
Other race/ethnicity percentage of enrollment	12.2	53.9	0.23	0.82	6.64	59.0	0.11	0.91	0.14	55.1	0.00	1.00
Percentage of males in community educated 9–11 years	–119.0	37.2	–3.19	0.00	–130.0	36.1	–3.60	0.00	–133.	39.5	–3.37	0.00
Percentage of males in community educated 13–15 years	–12.9	27.3	–0.47	0.64	–15.9	28.0	–0.57	0.57	5.36	32.5	0.16	0.87
Percentage of females in community educated 9–11 years	41.0	40.6	1.01	0.32	47.0	40.4	1.17	0.24	45.5	45.5	1.00	0.32
Percentage of females in community educated 13–15 years	–32.2	39.9	–0.81	0.42	–33.1	41.6	–0.80	0.43	–52.6	43.4	–1.21	0.23
Teacher years of service	0.13	0.33	0.40	0.69	0.12	0.34	0.35	0.73	0.29	0.35	0.83	0.41
Interaction of average daily enrollment and pupil-teacher ratio	0.00	0.00	1.16	0.25	0.00	0.00	1.34	0.18	0.00	0.00	0.71	0.48
Leader participation	0.68	0.76	0.89	0.37	0.51	0.79	0.65	0.52	0.75	0.86	0.88	0.38
Math teacher participation	2.63	2.18	1.21	0.23	2.74	2.24	1.22	0.22	2.76	2.45	1.13	0.26
Science teacher participation	–3.18	2.34	–1.36	0.18	–3.19	2.42	–1.32	0.19	–3.39	2.64	–1.28	0.20

NOTE: Comparison group 1 (n = 442 school districts) consists of non-MSP Pennsylvania school districts, excluding Pittsburgh and Philadelphia city school districts and a district with no enrolled students. Comparison group 2 (n = 412 school districts) excludes districts from group 1 that participated in the Philadelphia math and science partnership. Comparison group 3 (n = 338 school districts) excludes districts from group 2 that, though not members of the MSP, participated in some MSP activities. The MSP group (n = 48 school districts) excludes six MSP districts that did not join the project until 2006. District covariates included in models are those among the 106 pre-MSP covariates used in the propensity-weight process that did not balance well ($p < 0.05$, that differences between the MSP group and weighted comparison group were due to chance).

Table A.41
State-Level Regression Results for Mathematics, Cohort J (Grade 8 in 2006–07)

	Comparison Group 1				Comparison Group 2				Comparison Group 3			
Variable	**Coef.**	**Std. Err.**	**t**	**p-value**	**Coef.**	**Std. Err.**	**t**	**p-value**	**Coef.**	**Std. Err.**	**t**	**p-value**
Math proficiency levels in 2003–04 (grade 5)	0.32	0.08	4.14	0.00	0.31	0.08	3.95	0.00	0.33	0.07	4.55	0.00
Hispanic percentage of enrollment	–18.8	24.2	–0.77	0.44	–14.0	30.2	–0.46	0.64	–37.5	29.2	–1.28	0.20
Black percentage of enrollment	–45.1	7.1	–6.35	0.00	–44.8	7.22	–6.21	0.00	–46.0	7.67	–6.00	0.00
Other race/ethnicity percentage of enrollment	77.4	57.8	1.34	0.18	69.2	61.9	1.12	0.26	99.5	65.7	1.52	0.13
Percentage of males in community educated 9–11 years	–54.4	36.5	–1.49	0.14	–60.9	35.8	–1.70	0.09	–52.9	35.2	–1.50	0.13
Percentage of males in community educated 13–15 years	9.18	32.8	0.28	0.78	7.32	34.3	0.21	0.83	8.82	32.6	0.27	0.79
Percentage of females in community educated 9–11 years	–54.4	47.5	–1.14	0.25	–54.9	48.7	–1.13	0.26	–36.8	45.4	–0.81	0.42
Percentage of females in community educated 13–15 years	7.33	41.6	0.18	0.86	2.89	44.4	0.07	0.95	25.3	39.8	0.64	0.52
Teacher years of service	–0.54	0.39	–1.38	0.17	–0.58	0.40	–1.44	0.15	–0.43	0.41	–1.04	0.30
Interaction of average daily enrollment and pupil-teacher ratio	0.00	0.00	–2.36	0.02	0.00	0.00	–2.00	0.05	0.00	0.00	–2.10	0.04
Leader participation	2.79	0.97	2.87	0.00	2.83	1.01	2.79	0.01	2.79	1.07	2.62	0.01
Math teacher participation	0.76	1.96	0.39	0.70	0.77	2.03	0.38	0.70	0.89	2.21	0.40	0.69
Science teacher participation	–4.59	2.34	–1.96	0.05	–4.65	2.42	–1.92	0.06	–5.18	2.63	–1.97	0.05

NOTE: Comparison group 1 (n = 442 school districts) consists of non-MSP Pennsylvania school districts, excluding Pittsburgh and Philadelphia city school districts and a district with no enrolled students. Comparison group 2 (n = 412 school districts) excludes districts from group 1 that participated in the Philadelphia math and science partnership. Comparison group 3 (n = 338 school districts) excludes districts from group 2 that, though not members of the MSP, participated in some MSP activities. The MSP group (n = 48 school districts) excludes six MSP districts that did not join the project until 2006. District covariates included in models are those among the 106 pre-MSP covariates used in the propensity-weight process that did not balance well ($p < 0.05$, that differences between the MSP group and weighted comparison group were due to chance).

APPENDIX B

Teacher and Principal Survey Development and Methods

This appendix contains information about the survey development and analysis related to the findings reported in Chapter Five.

Teacher Survey

To develop the teacher survey, we reviewed existing survey instruments from several related studies of instructional practice, such as Horizon Research's *Looking Inside the Classroom* (I. Weiss, Pasley, et al., 2003), RAND's Mosaic II project, instruments from Michigan State University's TIMSS Study Center, and the Council of Chief State School Officers' Surveys of Enacted Curriculum. We selected the Surveys of Enacted Curriculum based on their ability to measure the types of teacher practice and course content reforms targeted by the MSP intervention (Porter, 2002). However, because these surveys must be administered near the end of the academic year and require 60–90 minutes for completion, we were concerned about our ability to achieve acceptable response rates with the instruments in their current form.

In consultation with colleagues, we determined that 30–45 minutes was a more reasonable length for this survey. Therefore, we modified the survey by deleting items so that the expected completion time would fall into this range. The criteria we used to determine which items to delete were based on the relevance of each survey item to the MSP intervention. We preserved those items that we expected to be affected most strongly by the project. A pilot test was conducted to ensure that the modified instrument maintained coherence and could be completed in the targeted amount of time. Our adaptation of the survey instrument was created with permission of the survey developers.

The teacher population of interest for our survey was all teachers in the original 40 MSP districts who specialize in math or science or who teach at least one math or science class. At the elementary-school level, this meant that the population often included most teachers in each school. We drew a stratified random sample of the population for inclusion in the survey, oversampling teachers involved in the MSP LATs. Elementary-school teachers sampled to answer the survey were randomly assigned either the math or science survey if they taught both subjects.

The survey was conducted online, with a paper survey available to teachers who were unable or unwilling to complete the survey online. Sample and response rates are presented in Table B.1.

Table B.1
Teacher Survey Sample and Response Rates

Survey	Responses	Sample	Total Population	Response Rate (%)
Baseline	1,241	1,881	3,200	66
Follow-up	1,574	1,988	3,440	79

Principal Survey

The principal survey was designed to capture changes in principals' views and attitudes toward science and mathematics instruction; current practices and policies regarding curriculum, instruction, assessment, and professional development; district and IU support for improving schools; and MSP project impact. Survey items were adapted from survey instruments developed by Horizon Research, Inc., the Center for the Study of Teaching and Policy, and the Center for Research on the Context of Teaching and from principal rubrics developed by Richard Halverson at the Wisconsin Center for Education Research. We also shared early drafts of our principal survey with the MSP PI and co-PI and received valuable input on refining the survey items to reflect areas of MSP impact.

The survey consisted of six sections. The first two sections focused on views and influences on mathematics/science instructional practices and asked principals to provide their opinions about lesson design and implementation; instructional practices; classroom resources; assessment of student learning; government (federal and state), regional/district, and school policies; instructional materials and resources; and teacher support. The third section included the most diverse set of survey items, with questions focusing on principal practices related to curriculum, instruction, and assessment, with a number of questions about the types of professional development activities in which the principals participate, including those offered by the MSP. The fourth section, on district and IU support for improving schools, solicited principals' views on the extent to which districts and IUs facilitate supportive environments for many of the MSP-promoted practices. Principals were also asked to rate the MSP staff's role in supporting school efforts to implement MSP practices, such as data collection and analysis, development of standards, and staff development. The fifth section focused solely on MSP project impact, asking principals to judge the impact of activities included in the MSP action plan. Finally, the sixth section collected information about the principals' background and included items on content expertise, years as principal/assistant principal, ethnicity, and academic degree.

The baseline principal survey was fielded online in late 2004, with paper surveys available to principals who requested them. The survey was distributed to 201 principals (one from each school in the 48 MSP districts—NSF- and PDE-funded). The overall response rate was 71 percent, and 11 percent of these responses were on paper. The response rate for the follow-up survey, fielded in late 2006, was 92 percent (181 of 197). Surveys were received in both years from 129 schools. From 2004 to 2006 there was considerable turnover among principals in the MSP schools. As a result, the follow-up sample included only 118 of the 201 principals who had been sampled in 2004, and 84 of these responded to both surveys.

Notably, the turnover among principals resulted in a shift in some of the demographic variables summarized in Table B.2. In general, principals responding in 2006 reported

Table B.2
Principal Survey Respondent Demographics

Characteristic	2004 Survey (%)	2006 Survey (%)
Gender		
Female	46	47
Race		
White	90	91
Black	6	7
Years as principal in the district		
> 10	19	9
7–10	24	20
4–6	26	29
2–3	19	24
0–1	11	19
Highest degree earned		
Doctorate	28	21
Master's +	29	35
Master's	42	43

fewer years of experience in their district than did those who responded in 2004 (Cochran-Armitage Trend Test, $p < 0.01$). In 2006, 9 percent of principals reported having more than 10 years of experience as a principal in the district, while 19 percent reported having one year or less. In 2004, these values were approximately reversed: Nineteen percent reported having more than 10 years of experience, while 11 percent reported having one year or less. A similar trend, though nonsignificant, appears in the educational degrees reported, with fewer principals in 2006 holding a doctorate degree and more with a master's degree plus additional coursework.

Factor Analysis of Principal and Teacher Survey Data

The principal surveys consisted of sections pertaining to views and influences on mathematics and science instruction; current practices and policies regarding curriculum, instruction, assessment, and professional development; and district and IU support for improving schools. Each section included questions that had between four and 25 subquestions using Likert-type scales (e.g., 1 = strongly disagree, 5 = strongly agree). The teacher surveys consisted of sections pertaining to instructional activities, assessments, instructional influences, classroom preparation, and professional development for math and science in high school or K–8. Each section included questions that had between five and 12 subquestions. The goal was to develop scales that would summarize these sections.

Factor analysis was used to determine the grouping of variables in each section. To be more specific, factor analysis was used to uncover the latent structure (dimensions) of a set of variables. In essence, we used the factor analysis for the following purposes:

- to select a subset of variables from a larger set, based on which original variables have the highest correlations with the principal component factors
- to validate a scale or index by demonstrating that its constituent items load on the same factor and to drop proposed scale items that cross-load on more than one factor.

After factor analysis, a descriptive name was attached to each common factor once it was extracted and identified. The assigned name is indicative of the predominant concern that each factor addresses. At this point, the named common factors can now be used as independent or predictor variables. However, a reliability test is meaningful for all the factors before they are used in subsequent analyses.

Reliability comes to the forefront when variables developed from summated scales are used as predictor components in objective models. Because summated scales are an assembly of interrelated items designed to measure underlying constructs, it is very important to know whether the same set of items would elicit the same responses if the same questions were recast and readministered to the same respondents. Variables derived from test instruments are declared reliable only when they provide stable responses over repeated administration of the test.

To test the reliability of the factors (or scales), Cronbach's alpha was calculated. Computation of alpha is based on the reliability of a test relative to other tests with same number of items and measuring the same construct of interest (Hatcher, 1994). The alpha coefficient ranges in value from 0 to 1. The higher the score, the more reliable the generated scale. Nunnally (1978) has found 0.7 to be an acceptable reliability coefficient, but lower thresholds are sometimes used in the literature. For nearly all of our scales, alpha is > 0.60 (as reported in Tables 5.1 and 5.2 in Chapter Five). For each scale, the dispensable variable or variables were identified by listing the deleted variable with the expected resultant alpha. If alpha was improved, then the dispensable variables were removed from the scale. In other words, the removing of a variable from the scale will make the construct more reliable for use as a predictor variable.

Once a scale was established, tests for normality (including the Shapiro-Wilk test) were performed. When scales were normally distributed, comparisons between groups were made using a t-test or ANOVA (analysis of variance), where applicable. Where the distributions were not normal, comparisons between groups were made using a Kruskal-Wallis test or signed-rank test, where applicable. In all cases, p-values less than 0.05 were considered evidence of differences not attributable to chance. All analyses were performed with use of SAS® 9.1 (SAS Institute, 2004).

Imputation of Missing Values

For each of the four surveys (baseline and follow-up, teacher and principal), we imputed responses that were missing on surveys that we received. Generally, there were few missing items. Additionally, we imputed response values for the entire survey for nonrespondents on the baseline and follow-up principal surveys and on the follow-up teacher surveys. The response rates for those surveys were discussed earlier in this appendix; each was 71 percent or greater. The imputations enabled us to make inferences about the full population of principals, and, in combination with sample weighting, enabled us to make inferences about the full population of teachers. Multiple (five) imputations of missing values were performed using a multivariate technique consisting of a sequence of stepwise regression models. Imputations were performed separately for each year and each subject (math and science). Possible predictor variables in each model consisted of all item-level responses for a given year, as well as teacher, school, and district demographics. To check that the imputation models performed reasonably in recovering the missing data, we examined the pre- and post-imputation data to confirm that the imputation did not produce unexpectedly large changes to item-response patterns. For example, on the follow-up teacher survey for mathematics teachers, out of 148 survey items, the absolute difference in item means from pre- to post-imputation averaged 0.08 points on the survey scale, and the greatest change in mean for any single item was 0.26 points. All subsequent analyses of the imputed data adjust for the between- and within-imputation variability—that is, all subsequent statistical tests account for the uncertainty introduced by the imputation.

Statistical Models for Survey Analysis

We ran hierarchical linear models that account for the clustering of teachers in schools and districts to assess how responses changed. In all cases, two-sided tests were used with p-values for rejecting the null hypothesis set lower than 0.05 to correct for multiple-hypothesis testing. Here, we describe the statistical models used in the analysis of the teacher and principal survey data.

Teacher Survey

Teacher survey data were analyzed separately for each subject (mathematics and science) and grade level (high-school survey or K–8 survey). We stratified on these variables to avoid bias that could be introduced from the sampling mechanism. The mixed model used to analyze the data can be broken down into two levels:

$$Y_{ij} = B_{0j} + r_{ij}.$$

This equation models teacher-level effects, where B_{0j} is the intercept for the teacher's school, and r_{ij} is the random effect for *i*th teacher at the *j*th school. The within-school random error, r_{ij}, is considered to be normally distributed with mean zero and variance σ^2. The outcome, Y_{ij}, is the difference in the *i*th standardized teacher survey scale between 2007 and 2004 in the *j*th school. Both the 2004 and 2007 survey scales were standardized using the standard deviation for 2004. Twelve survey scales and all individual items in the assessment scale were analyzed in separate models. The second level of the model is as follows:

$$B_{0j} = \gamma_{00} + \gamma_{01}\left(P_{j1}\right) + \gamma_{02}\left(P_{j2}\right) + \gamma_{03}\left(P_{j3}\right) + \mu_{0j}.$$

This breaks down the intercept term for each school, B_{0j}. It includes a term for the overall mean, γ_{00}, and three school-level fixed effects: γ_{01}, γ_{02}, and γ_{03}, representing the effects of

MSP participation of district-level leaders, school-level leaders, and teachers. Participation by these educators at school j is represented by P_{j1}, P_{j2}, and P_{j3}, respectively. Teacher participation was subject-specific for the analyses performed on high-school teachers, but for the K–8 teacher analysis, the participation of teachers in both subjects was combined because it is common for teachers of lower grade levels to teach both subjects. The participation variables were a cumulative sum of participation in MSP through the 2006–07 school year. The variance of the among-school random effect, μ_{0j}, is modeled as having a normal distribution with mean of zero and a variance of τ^2.

Each imputation dataset was tested separately and combined using PROC MIANALYZE in SAS. In considering the multiple tests performed for each scale of the teacher survey, we applied a Bonferroni least significant difference adjustment to the overall significance level of the F tests, dividing the significance level of 0.05 by the number of tests, l.

Principal Survey

The modeling approach used in the principal survey was again a mixed model, this time including only participation data for school leaders at the district and school levels as well as a variable indicating the number of school leaders participating in principal seminars. The participation variables are cumulative sums of participation hours through the 2005–06 school year. The mixed model used to analyze the data is as follows:

$$\text{Level 1: } Y_{ij} = B_{1j} + r_{ij}$$

$$\text{Level 2: } B_{1j} = \gamma_{10} + \gamma_{11}\left(P_{j1}\right) + \gamma_{12}\left(P_{j2}\right) + \gamma_{13}\left(P_{jP}\right) + \mu_{1j},$$

where changes in standardized survey scales from 2004 to 2006, Y_{ij}, were modeled as a linear combination of B_{1j}, the intercept for the principal's school, and r_{ij}, the random effect for ith principal at the jth school. r_{ij} is normally distributed with mean zero and variance σ^2. Seventeen survey scales were analyzed in separate models. The intercept term for each school, B_{1j}, is modeled as a linear combination of the overall mean, γ_{00}; two school-level participation fixed effects, γ_{12} and γ_{13}, represent MSP participation of school leaders at the district $\left(P_{j1}\right)$ and school $\left(P_{j2}\right)$ levels; and a third school-level fixed effect, γ_{13}, is a count of educators in the school who attended principal seminars $\left(P_{jP}\right)$. The variance of the school random effect, μ_{1j}, is modeled as having a normal distribution with mean of zero and a variance of τ^2.

Each imputation dataset was tested separately and combined using PROC MIANALYZE in SAS. For each family of tests of size n, a least significant difference adjustment of 0.05/n was performed to the overall level of significance.

APPENDIX C

Qualitative Analysis of IHE Data

This appendix contains additional information about the methods used for the qualitative analyses of IHE data reported in Chapters Five and Six.

Data Sources

The primary data source for the IHE qualitative analyses was semistructured individual interviews with IHE STEM and education faculty members; administrators, including deans, department administrators, and coordinators of student-teacher placements; student teachers; and K–12 teachers participating in the TF program. From 2004 through 2008, we conducted interviews of 56 IHE-affiliated faculty members and administrators, including deans, department administrators, and student-teacher placement coordinators. We used purposive sampling to gather information from STEM faculty members in math and science and from science and math education faculty members as well as to select the faculty members who were interviewed more than once. In addition, we interviewed 10 TFs (at least two from each IHE), four student teachers, and four K–12 teachers who supervised student teachers. In sum, we conducted a total of 118 interviews. In addition to the individual interviews, we conducted three focus groups with TFs who had completed the TF program. Supporting data sources consisted of four IHE classroom observations, documentation review of IHE course syllabi and curricula, questionnaires regarding MSP course revision, MSP and K–20 partnership literature, and the NSF's Management Information System, a database of information from annual surveys of all Math and Science Partnership projects.

Analysis

Interviewer notes from the interviews and focus groups were analyzed using the qualitative data management software, ATLAS.ti (Muhr, 2004). For the focus group data, recordings of the discussions were archived as a reference from which to draw direct quotations for the analysis. Questions from the interview protocol provided the basis for the preliminary list of codes, which was refined based on input from interviewers and new themes found in the interviews. Two researchers worked together to develop the final code list, and one researcher was responsible for the coding to ensure the consistent application of codes to the data.

For analyses related to partnership conceptualization and development, three sources of data were used to build construct validity and the reliability of findings and conclusions (Yin, 2003): (1) MSP and K–20 partnership literature, (2) semistructured interviews, and (3) existing MSP Management Information System online survey reports and annual project reports. MSP and K–20 partnership literature was used to build the theoretical framework necessary to interpret the empirical data, to inform code development, and to support or challenge our findings. The first mode of inquiry that we employed in this study was a review of the MSP and K–20 literature to establish a theoretical framework that allowed us to operationalize *partnership* and *partnership development*. However, the main methodology employed in this study was qualitative data analysis. Using existing MSP and K–20 partnership literature and our research questions, we developed a list of descriptive and pattern codes. This a priori list of "parent" codes included such codes as institutional factors, MSP impact, partnership, and sustainability. The parent codes provided an organizational structure that enabled us to expand these codes into subcodes as needed. Descriptive accounts were then coded to create a systematic way to group like descriptions of partnership development and to compare different descriptions of partnership development.

The first iteration of coding was descriptive: The entire interview was coded with parent and subcodes, allowing us to classify and count various responses related to our research questions. The second iteration of coding was more interpretive: We attempted to identify patterns and explanations. For this level of analysis, we focused primarily on the interview segments that were coded with the *institutional factor* and *partnership* parent codes. Focusing on just these data, we coded for partnership conceptualizations and factors that indicated partnership development based on our review of the literature. Throughout the data-analysis process, we looked for disconfirming and confirming evidence to create an accurate and nuanced account of partnership development (Erikson, 1986). Interviews were coded until codes were saturated and sufficient numbers of regularities emerged (Miles and Huberman, 1994).

We analyzed both IHE faculty and K–12 educator interviews. Data were collected on 42 IHE faculty (STEM and education) and 10 K–12 educators from all four IHEs between 2004 and 2007. Although many of the 42 IHE faculty members were interviewed repeatedly over the three years of data collection, we included only the most recent interview for each IHE faculty member in our sample. The most recent interviews were analyzed because conceptualizations of partnership and beliefs about partnership development from these interviews had the most relevance with regard to sustaining the project. In sum, eight IHE faculty interviews were analyzed from year 2 (2004–05), seven were analyzed from year 3 (2005–06), and 27 were analyzed from year 4 (2006–07).

The 10 interviews with K–12 educators who had participated in the TF program were also analyzed. The TF program is a unique program that provides K–12 educators an opportunity to spend one or two semesters at a partner IHE, working alongside faculty to revise undergraduate courses, take college courses, and assist in other MSP activities. Four K–12 educator interviews were analyzed from year 2 (2004–05), four were analyzed from year 3 (2005–06), and two were analyzed from year 4 (2006–07).

Finally, we examined the Management Information System and previous annual project reports to gather participation and demographic information about our sample. Our review of the MSP and K–20 partnership literature suggested there were at least five characteristics that might influence faculty participation and attitudes about partnership development: IHE faculty department, IHE faculty tenure status, MSP activity participation, IHE faculty participation level throughout the MSP, and gender. We found our sample to be fairly evenly distributed across these five characteristics (see Table C.1).

Table C.1
IHE Faculty Member Characteristics

Characteristics	Number of interviewees
Department	
Mathematics	10
Science	16
Education	10
Education and mathematics	4
Education and science	2
Tenure status	
Tenured	16
Not tenured	17
Not applicable	9
Participation level	
> 160 hours	8
81–160 hours	10
20–80 hours	13
< 20 hours	9
Not applicable	2
Gender	
Male	23
Female	19

Classroom Observation Methodology

Between spring 2007 and spring 2008, a total of four IHE classroom observations were conducted—one at each of the four IHEs. The primary goal of the classroom observations was to provide a more in-depth description of the changes in instructional practices reported by IHE faculty. However, a secondary goal of the classroom observation was to gain a better understanding of the nature of the course revisions. Thus, we specifically asked to observe courses that had been revised by TFs. For all except one of the observations, we were able to observe a lesson from a course that had been revised by a TF. The observational protocol that we developed consisted of a set of items that asked the observers to describe the types of instruction implemented by the IHE faculty, the level of student involvement, and student cognitive activity. These items were drawn from the classroom observation protocol developed for the NSF's Collaboratives for Excellence in Teacher Preparation program (Lawrenz, Huffman, and Appledoorn, 2002).

We observed a single class session at each of the IHEs; overall, these sessions included one introductory science class, one advanced-level science class, one introductory mathematics class, and one advanced-level mathematics class. We interviewed IHE faculty members prior to and immediately following the classroom observations. The pre-observation interview was used to establish important contextual features of the observation. For example, we asked where this lesson fit in the overall structure of the course, how much previous material the class had reviewed on this topic, and the level of the course. The post-observation interview gathered data on the faculty member's perception of how well the class went, the extent to which the faculty member covered the desired amount of material at the expected level of detail, the strongest and weaker aspects of the class, and how MSP-promoted practices were utilized. Each interview lasted approximately 30 minutes.

Two researchers were on site to conduct the observation. Lessons were observed for the full class period. Within a week of the observation, researchers completed an MSP Program Aims and Reflections Form, which was used to describe the lesson along the following program elements: (1) lesson design, (2) learning culture, and (3) lesson implementation. These notes were more free-form and were used to link what was observed in the classroom to specific MSP program aims. Observers also noted on this form any unique or unexpected activity that may have occurred in class. Field notes and completed observation protocols were shared among team members to note any variation in how the forms were completed and to analyze findings.

MSP Course Revision Questionnaire

To better understand the nature of the course revision and its eventual impact, the MSP Course Revision Form was developed by IHE faculty in collaboration with the RAND research team and administered to the IHE faculty in the winter of 2007–08. The form was designed to assess different aspects of the revised course, including how the revisions changed the course, the overall value of the teacher fellow to the course revision, and the anticipated impact of the revision on student learning.

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